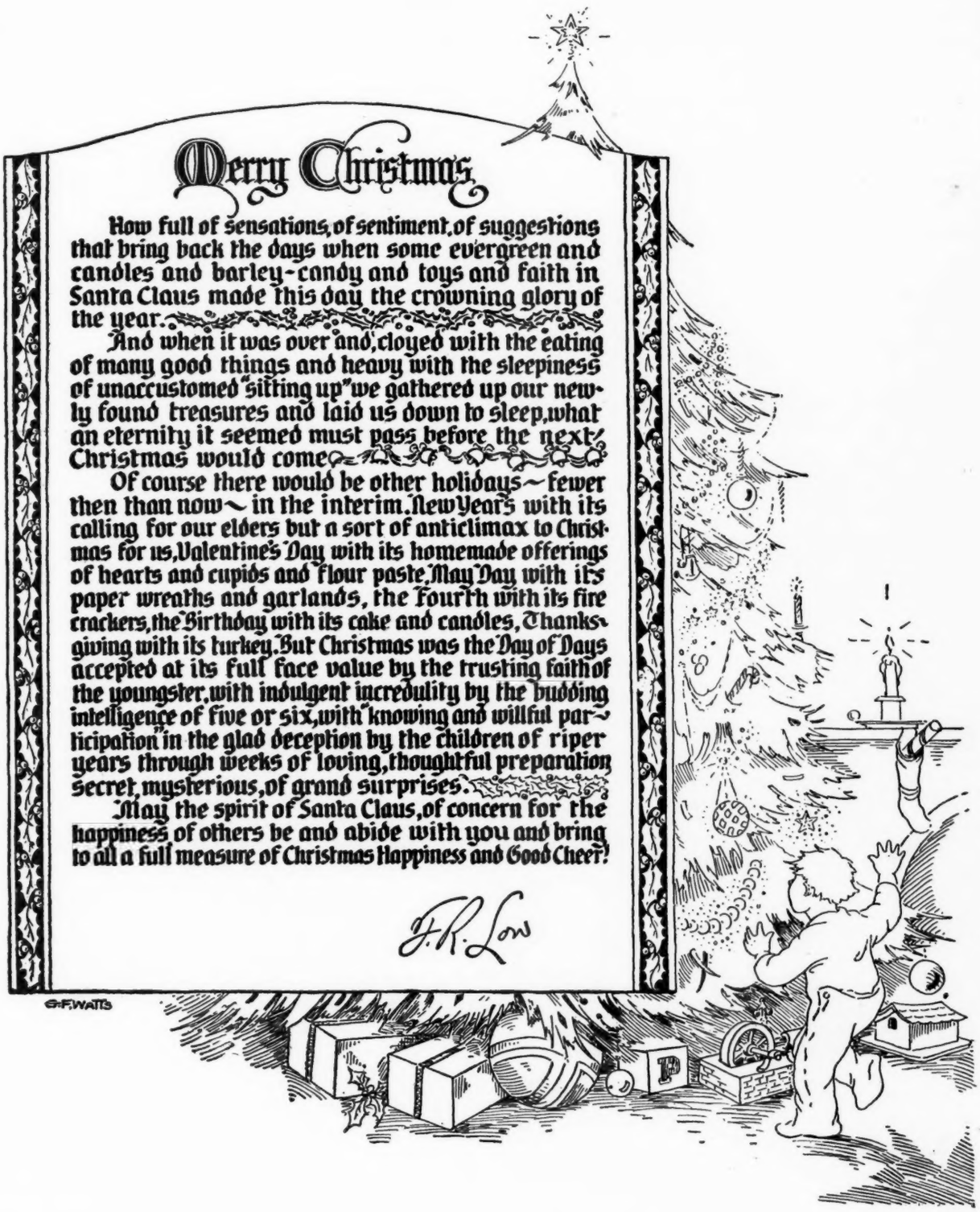
POWER

Volume 60 New York, December 23, 1924 *No.* 26


Merry Christmas
How full of sensations, of sentiment, of suggestions that bring back the days when some evergreen and candles and barley-candy and toys and faith in Santa Claus made this day the crowning glory of the year.
And when it was over and, cloyed with the eating of many good things and heavy with the sleepiness of unaccustomed "sitting up" we gathered up our newly found treasures and laid us down to sleep, what an eternity it seemed must pass before the next Christmas would come.
Of course there would be other holidays — fewer then than now — in the interim. New Year's with its calling for our elders but a sort of anticlimax to Christmas for us, Valentine's Day with its homemade offerings of hearts and cupids and flour paste, May Day with its paper wreaths and garlands, the Fourth with its fire crackers, the Birthday with its cake and candles, Thanksgiving with its turkey. But Christmas was the Day of Days accepted at its full face value by the trusting faith of the youngster, with indulgent incredulity by the budding intelligence of five or six, with knowing and willful participation in the glad deception by the children of riper years through weeks of loving, thoughtful preparation secret, mysterious, of grand surprises.
May the spirit of Santa Claus, of concern for the happiness of others be and abide with you and bring to all a full measure of Christmas Happiness and Good Cheer!
J. R. Low
G. F. WATTS

High Bridge Steam Plant at St. Paul

Initial 60,000-kw. installation of big base-load steam plant to supply St. Paul and surrounding territory and supplement the water power of the Northern States Power Co. Simplicity, convenience of operation, and economy correlated with interest charges were the guiding factors in the design. Underfeed stokers were preferred to pulverized fuel, two-stage bleeding in conjunction with a fair proportion of steam-driven and dual-drive auxiliaries were adopted and evaporators were used to purify the water. Economizers, air preheaters and house turbines were omitted.

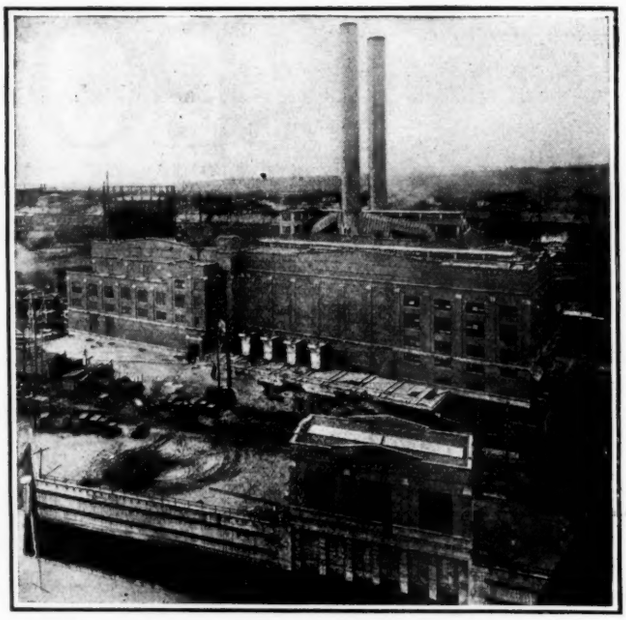


Fig. 1—New Byllesby High Bridge station of Northern States Power Co.

ON THE left bank of the Mississippi River between St. Paul and St. Paul West, the Northern States Power Co., a Byllesby subsidiary, is completing the first two-unit section of a new steam power plant that ultimately will contain eight units and will be the big base-load plant of the entire system. The present installation consists of two 30,000-kw. units, each served by four boilers, and as future units will be of the same size or larger, a final generating capacity of at least 240,000 kw. is expected. Generally, each succeeding section will duplicate the original installation and make up a distinct unit division of the plant. Upon each occasion it will be necessary to add to the length of the building and extend the coal- and ash-handling facilities. The switchhouse and the electric control system have been laid out with the ultimate plant in view, and already provision has been made to supply condenser cooling water to the first two sections.

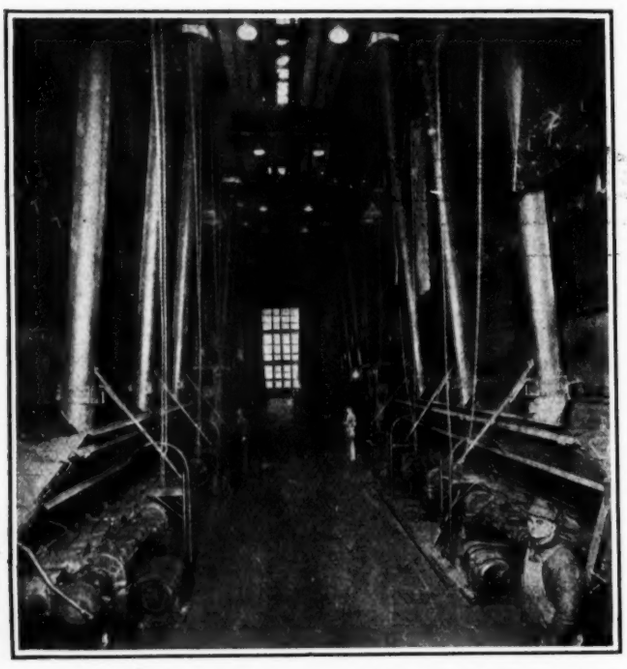


Fig. 2—View in boiler room of High Bridge station

There was urgent need for the new plant as the load on the system had been increasing rapidly to a point where it exceeded the minimum hydro-electric capacity and had loaded up the Riverside steam plant in Minneapolis. From St. Paul the electrical demand was becoming excessive for the lines over which the supply was carried, so that the natural site for the new plant was one providing an ample water supply, good railway trackage facilities for coal delivery and at the same time giving the best assurance of service to St. Paul.

With these factors in view the best site for the plant was in St. Paul, near High Bridge, a highway crossing 125 ft. above the Mississippi River. At practically the same point was an important substation receiving energy from Minneapolis and from the Rapidan and Cannon Falls hydro-electric plants. From the Wissota plant a 110,000-volt line came into South St. Paul and into the Terminal substation and Riverside steam plant in Minneapolis. The latter two stations are on the north side of the city and South St. Paul is south of both cities. By running a line from the Riverside station around the south side of Minneapolis to South St. Paul and tying in the new High Bridge plant, a 110,000-volt loop around the Twin Cities was completed, making readily available the major portion of the water and steam power of the entire system and promoting an interchange between the various sources of supply. Each station constitutes a reserve for the others, insuring continuity of service and lessening the need for duplication of equipment in the individual plant.

In the layout of the plant, simplicity and convenience of operation have been guiding factors. The design includes nothing radical. In the selection of equipment a balance was sought between the economy of B.t.u. and the economy of interest charges. On this basis some of the later refinements have been omitted, as a careful analysis showed that the overhead offset the gain. Following out the general plan of economy of production with minimum investment, there is little dupli-

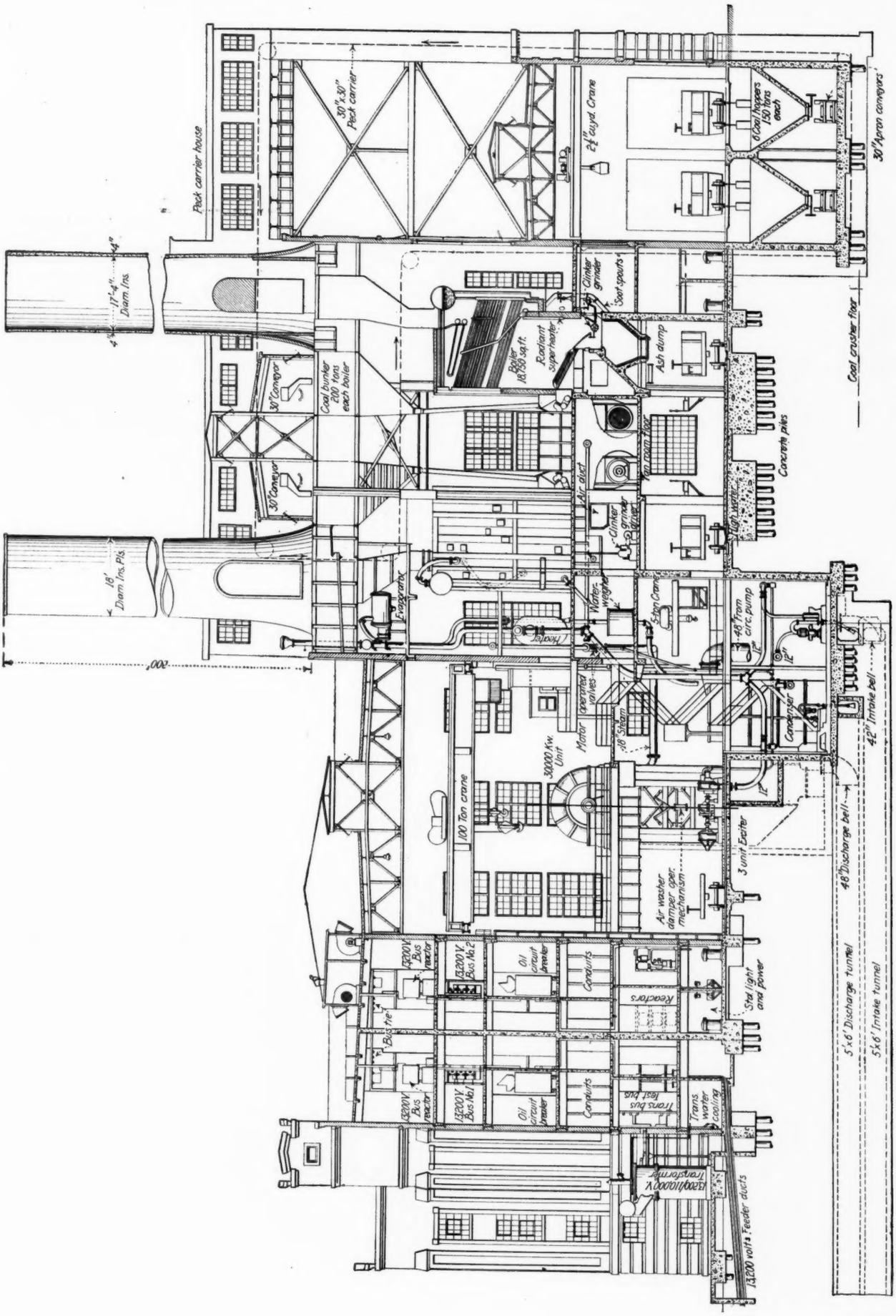


Fig. 3—Cross-sectional elevation of station

cation of equipment even in the auxiliaries. Reserve in the individual plant was considered an unnecessary expense with a multiplicity of stations tied in to a common loop.

One of the questions at issue was a choice between the use of powdered-coal equipment and mechanical stokers. A comparison based on the cost of production at the switchboard, including overhead, resulted in the selection of stokers, the decision being that the higher economies with powdered coal would be offset by the greater initial cost of the equipment and the increase in building cost owing to the additional space requirements. With an anticipated boiler efficiency of 78 per cent economizers did not show sufficient saving to warrant the investment. The favorable development of waste-heat air preheaters led to an attempt to apply them in the new station, but with the plant well under way proper space was not available.

As expressed by a company engineer, the only extravagances in the entire station were stage heaters and evaporators to supply pure water for boiler makeup. The character of the river water necessitated the use of evaporators or some other method of purification, and to insure a feed-water temperature in excess of 200 deg. for any load, stage heating at two points was adopted in conjunction with a diversity between steam and electric drive for auxiliaries. For example, the forced-draft fans and stokers are motor-driven. Turbines drive the boiler feed and service pumps. The circulating pumps and exciters have dual-drive, turbine and motor, while the smaller condenser auxiliaries use motors. There is no duplication of auxiliaries, but a fair division has been made between steam and electricity, so that the large dual drives give the flexibility needed to effect a heat balance.

One of the factors influencing the design of the plant and making it undesirable to excavate to any great depth was a rise and fall in the river level of 20 ft. between high and low water. This made it necessary to build a plant from grade up, with all openings into the station well above the high-water level. Two railway tracks at grade, 3 ft. above the high-water level, enter the boiler room for the removal of ashes, and at the same level a track enters the turbine room with sufficient headroom for box-cars. Other tracks provide for the unloading of coal into the plant conveying system and into storage.

Twenty-five feet higher up the main generating units rest on steel foundations the members of which are filled with concrete, but providing space for air washers underneath, each washer being an integral part of the closed system of generator ventilation employed. The fluctuation in river-water level called for the installation of vertical surface condensers located in a pit excavated to low-water level, 48 ft. below the operating floor. This pit or well has been made large enough to contain all boiler-feed and service pumps in addition to the condenser auxiliaries. As shown in the sectional elevation, it may be served by the turbine-room crane or by a small traveling crane at a lower level, which cares for the equipment on the boiler-room side of the pit out of reach of the larger crane. This is one of the unusual features of the plant that was worked out in the design and should be appreciated by the operating force.

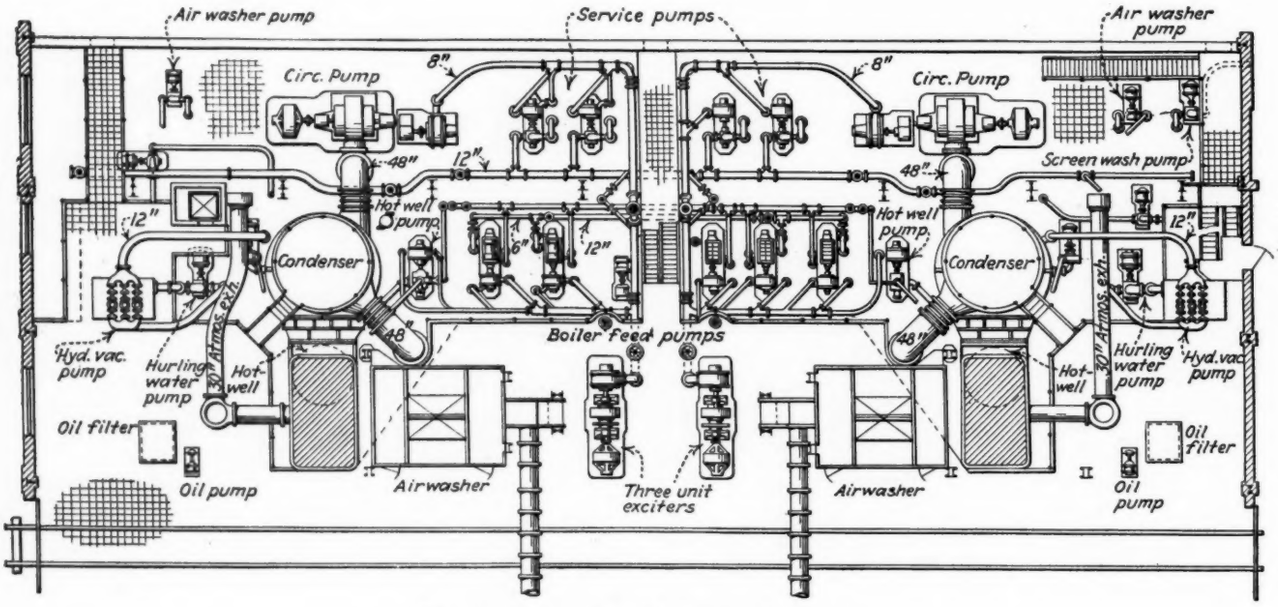


Fig. 4—Plan of turbine-room basement

In order that all parts of the turbine-room floor might be accessible to the crane, what is ordinarily considered the basement floor has been made the main floor, only a series of walkways being provided around the main unit at the operating level. The dual drive exciters are down below as indicated. This plan makes all equipment and the piping readily accessible, reduces the concentration of heat and provides much better lighting and ventilation. In this connection the condenser pit is lined with white enamel tile to improve the illumination.

At the end of the turbine room a large machine shop equipped to serve the ultimate plant has been provided. The extension is at the same level and of the same width as the turbine room, and the crane runway has been extended so that any machine or any portion of it within the turbine room may be conveyed directly to the repair department of the plant. Under the machine-shop floor is ample space for light and heavy

stores. Other features of the plant are the provision of space for a restaurant, as the site is not readily accessible, study and class rooms, a dormitory for a repair crew to stay overnight, first-aid rooms and the usual shower and toilet facilities for the operating crew. Full automatic freight elevators with micrometer adjustment serve the boiler room and the switchhouse, and three automatic passenger elevators provide for communication between the various levels of the plant.

In the boiler room the standard arrangement adopted by the company has been followed; that is, the boilers are on either side of a central firing aisle with overhead bunkers for each row of boilers and a light shaft between the bunkers topped by a monitor roof. Coal and ash handling are sealed from the boiler room. Other auxiliaries are placed at different levels along the dividing wall between the turbine and boiler rooms. For example, the water weigher is on the forced-draft fan floor, the plant heaters on the boiler-room floor and the evaporator at an elevation above the boilers.

Arrangement of Boilers

Boilers are of the double-deck type, each containing 18,750 sq.ft. of steam-making surface with the tubes arranged six high in the lower deck and twelve high in the upper deck. It will be noticed that the initial baffle has been arranged to expose a large percentage of the heating surface to the radiant energy of the fire. The bridge wall has been placed back well toward the rear, leaving only a 4½-ft. overhang, forming a convenient soot pocket connected to the ashpit by 10-in. cast-iron pipe. In this wall is a radiant superheater and above the tubes between the first and second passes is the usual convection superheater, this combination being preferred to the use of an interdeck superheater. With the dual arrangement more uniform superheat on varying loads than with either type of superheater alone, is anticipated. As the CO_2 goes up and furnace temperatures increase, the temperature in the convection superheater tends to drop off as a less quantity of gas is passing over the tubes, while in the radiant superheater the temperature rises. With the conditions reversed, the temperatures in the radiant superheater are lower and higher in the convection type of superheater, so that one superheater tends to correct the other and the two maintain a temperature practically constant.

Gases from the boiler rise through a vertical uptake, passing through the roof into a caterpillar breeching lined with 1½ in. of insulation, to a self-supporting steel stack located centrally, there being one stack for each row of four boilers. Gases from two of the boilers enter at one side of the stack, at the opposite side from the fourth boiler, and from the third boiler the gases pass directly up into the base of the stack. Rising 250 ft. above the boiler-room floor the stack has a net diameter of 17 ft. 4 in., being lined with 9 in. of firebrick for 25 ft. of its height and 4 in. of concrete for the rest of the way up. It is supported on girders tied into the building steelwork and resting on columns of unusual weight and depth to take care of wind pressure without the necessity of sway bracing at the sides of the boilers. This gives free access to the setting wall, and the aisle between boilers is maintained clear by using split column construction from a point above the boilers down to the column foundations. Each leg of a column forms the front corner of a boiler setting. The same columns help support the overhead bunkers.

Underfeed stokers serving the boilers have fourteen retorts and are equipped with clinker grinders so that clinkering coals can be burned without a falling off in capacity during cleaning periods. The stokers are driven individually by two induction motors of multi-speed design, speed variation being obtained by a manually operated drum-type controller changing the number of poles in the stator. A motor is mounted at either end of the stoker shaft on the boiler-room floor, the connection being a silent chain drive. The stoker shaft is split at the center so that the two motors

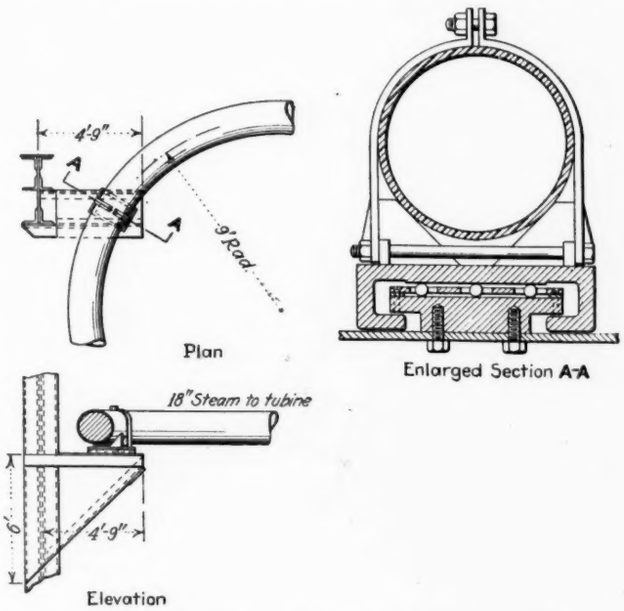


Fig. 5—Special all-bearing pipe support

operate and are controlled as a unit. In case of necessity provision is made to couple the two halves of the shaft and drive the stoker with one motor, as either has sufficient capacity. Following the same plan, two motors mounted on the floor below drive the clinker grinder.

Forced draft is supplied by full-housing double-inlet fans, one per boiler, directly connected to slip-ring induction motors. The motors have drum controllers at the boiler control panels on the main floor with the grid resistances in the basement near the motors. For every two boilers there is a control panel with six controls: two for the stoker motors, two for the fan motors and two for the clinker grinder motors. In Byllesby plants this arrangement is standard, as hand control of the fuel and air supply is preferred to automatic regulation. Normally, the fan supplies its individual boiler, but on either side the ducts are cross-connected so that operation on the common-duct plan may be carried out if desired.

Brick-lined concrete ashpits of 40 tons capacity receive the ashes from each stoker. Through pneumatically operated gates the ashes are discharged directly into standard railway cars from which they are transferred to the site for filling purposes. A feature of the ash floor is the walkways along the columns from which the operator can look into the car and watch results while he is manipulating the pneumatic control of the gates.

All high-pressure steam piping and boiler-feed lines are extra-heavy, with cast-steel valves and fittings, crane-lap joints and metal gaskets. The old-time header system has been discarded in favor of steel manifolds just long enough to receive the various connections; for example, the leads from four boilers serving a unit, two on either side of the firing aisle, a cross-connection from either end to the manifold serving an adjacent unit, and from the bottom an 18-in. connection for the supply line to the turbine. An auxiliary header connection is made at the same point to supply the steam-using auxiliaries in the plant at the usual boiler pressure and superheat. The operating conditions are 300 lb. gage pressure at the boiler and 250 deg. superheat, giving a final steam temperature of 672 deg. F. In the cross-connection between manifolds a U-bend cares for expansion and a motor-operated sectionalizing valve separates the two groups of boilers. For simplicity and accessibility much of the piping is concentrated in a pipe gallery on the fan floor.

In the longer runs of piping long-radius bends of six diameters are used wherever possible and massive hangers of bracket type with rollers top and bottom and springs to take the pulsations. In the turbine supply line a special type of ball-bearing support has been placed at the turn leading up into the turbine to prevent undue strain in the turbine shell. This pipe support rests on a bracket secured to a building column. It consists of a bearing plate, screwed onto the bracket, which supports a guide shoe mounted on ball bearings. The pipe is strapped to the guide shoe. From the sectional view, Fig. 5, it will be seen that an up-and-down motion is prevented while the pipe is free to move laterally in order to accommodate itself to expansion and contraction.

For fuel the plant has a wide range of coals to draw from, such as the supply from the Illinois and Indiana fields and eastern coals from Duluth or Superior, the latter being obtainable at a reasonable figure owing to the lake transportation. This is particularly true of dock screenings, which at times are a drug on the market. Either class of fuel will be used according to the number of B.t.u. that can be purchased for a cent. At present this basis favors eastern coals, but if the advantage should turn in the other direction, southern Illinois coal in particular can be burned to advantage on the underfeed stokers in the plant, provision for this fuel having been made by the installation of clinker grinders.

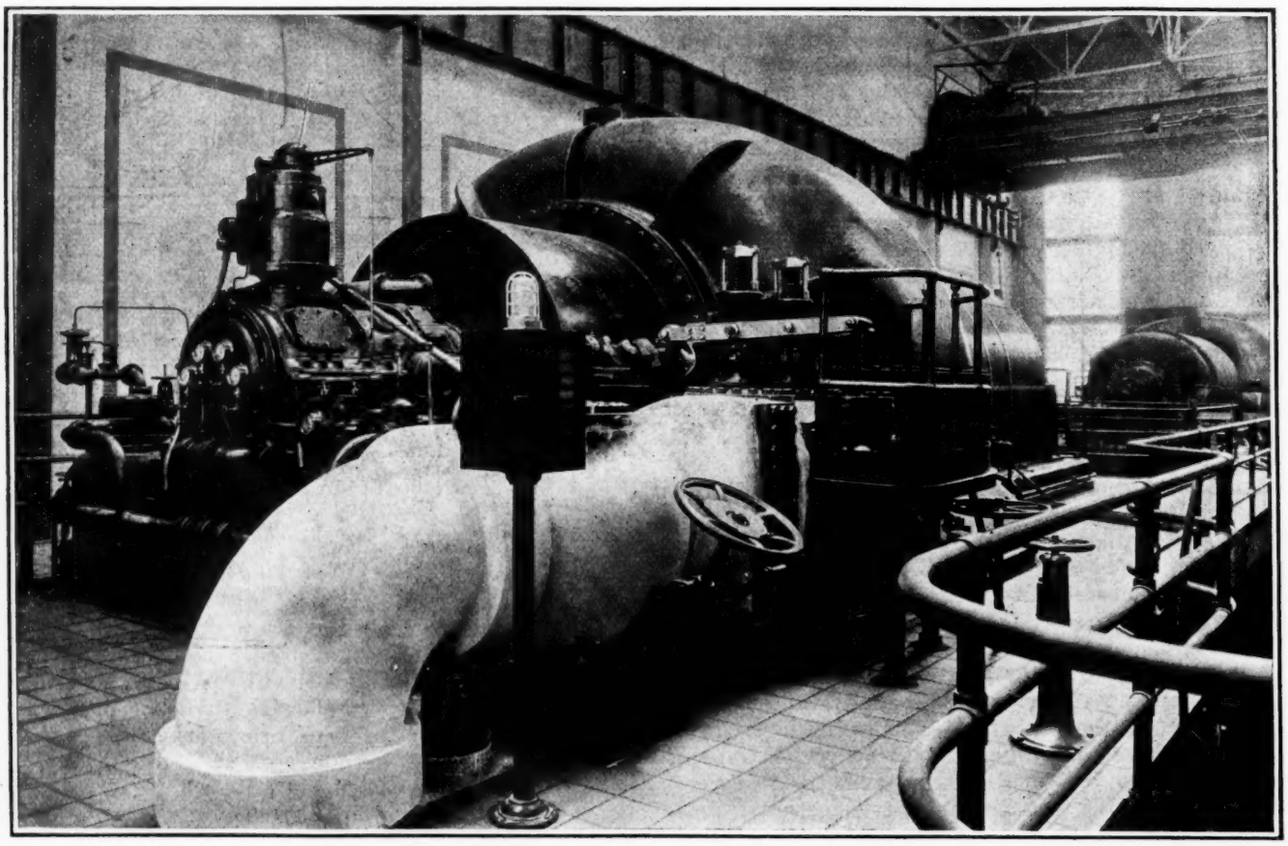


Fig. 6—Two 30,000-kw. units comprising initial installation

Double unloading tracks housed in at the side of the boiler room, with six hoppers per track, have been provided to care for the incoming coal, a traveling crane unloading cars that are not of the bottom- or side-dump types. From the track hoppers the coal is discharged onto 30-in. apron conveyors running to the far end of the coal house to deliver to a continuous bucket conveyor, being passed over a grizzley first to remove the fines and allow the coarser coal to pass through a 36-in. single-roll crusher of 200 tons capacity per hour. A tower and bridge to the plant house the continuous bucket carrier, which passes across the end of the present boiler room, delivering to belt conveyors running over and for the full length of the overhead bunkers. Owing to the unusual rise of 130 ft., the carrier links are made of forged steel. The belts are

equipped with automatic trippers, and the conveyor floors are of subway grating to prevent the accumulation of dust. All conveyors are motor-driven, with the starting compensator at the motor and push-button stops at several points which cut out simultaneously all motors of the conveying system.

On the site of 50 acres there is open storage capacity at present for 170,000 tons of coal. Locomotive cranes transfer the coal into storage, and a combination of locomotive crane and automatic dump cars take it out of storage and deliver it through the track hoppers into the conveying system. The dump cars are handled by a yard locomotive.

Water Purification

Water for plant use is drawn from the Mississippi River. It contains large quantities of silt, coming mostly from the Minnesota River which enters the Mississippi two miles above the plant, and is contaminated by sewage from Minneapolis and large manufacturing works along the stream. For boiler use purification was essential and was effected by the installation of a high-pressure double-effect evaporator system for the two units comprising the initial plant. Makeup water for the evaporators is drawn from the 12-in. service main of the station and, with a small evaporator storage tank in parallel to maintain a uniform supply, is delivered to the evaporator, the purified water passing to the open heater under float control.

Condensation from the hotwells of the main condensers is passed in sequence through the evaporator condenser and the two bleeder-type heaters taking steam from the fourteenth and eleventh stages of their

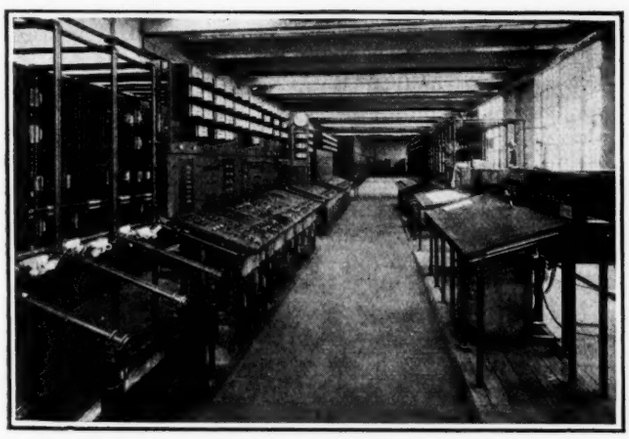


Fig. 7—Control room on top floor well lighted from the sides and above

respective turbines, to the open plant heater, where a temperature approximating 205 deg. F. is maintained. From the heater the water flows by gravity through the water weigher to the 12-in. boiler-feed suction header. Two turbine-driven boiler-feed pumps per unit are provided, and in addition there is a single boiler wash pump for the two units and an extra pump and water weigher for testing purposes. Duplicate boiler-feed lines are provided, with pump governors at the pumps and feed-water regulators at the boilers to control the supply. Low-pressure drips and drains are collected in two concrete sumps in the condenser pit and are pumped back to the open heater under float control. High-pressure drains are trapped directly into the heater.

Two turbine-driven pumps of 1,600 gal. per min. capacity each, draw the service water supply through strainers from the intake tunnel and deliver into the 12-in. service header, which is connected to a 30,000-gal. storage and pressure balancing tank mounted high up in the electrical gallery. The supply for the various house services is drawn from this main, including cooling water for transformers, makeup water for evaporators, cooling water for bearings in the main

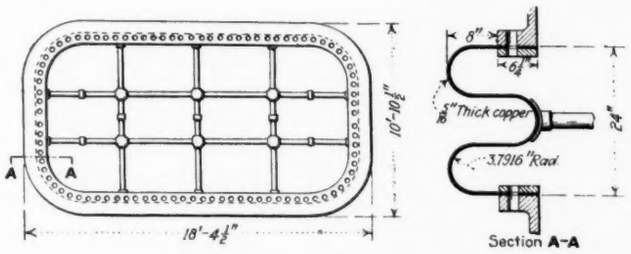


Fig. 8—Detail of turbine-condenser copper expansion joint

units and auxiliaries, water for the oil coolers and ash sprinkling and bypass emergency connections to the air washers. All header lines have valves at the center to separate the two units should it be desired to operate on the unit plan.

The Turbo-Generator Room

Mention has been made of the turbo-generator room. The main units, two in number, making up the initial installation, are each rated at 35,300 kva. or 30,000 kw. at 85 per cent power factor. The machines generate three-phase 60-cycle current at 13,200 volts. Separately driven exciters are employed, one for each unit. These are 300-kw. 250-volt machines with dual drives consisting of a steam turbine and a 2,300-volt induction motor. Ordinarily, the turbine drive will be used, particularly in the winter months when there is considerable demand for exhaust steam for heating the building in addition to the heat-balance requirements. The motor is considered in the light of an emergency drive to be cut in automatically should the turbine be incapacitated from any cause.

Ventilation of each main generator is effected by a closed system in which the air is circulated by the generator fan through an air washer under the base of the machine and back through the windings. In case of a rise in generator temperature, a thermostatic alarm bell gives warning so that the operator may trip by hand a hydraulic valve which, by opening a damper in the system, bypasses the air washer. The air supply is then taken from and delivered back into the turbine room.

The prime movers are 17-stage machines of Curtis type operating at a speed of 1,800 r.p.m. At the most economical load, 27,000 kw., the guaranteed steam rate is 9.6 lb. per kilowatt-hour.

Between the turbine exhaust nozzle and the vertical condenser inlet casting, a vertical clearance space of two feet prohibited the use of the usual type of copper expansion joint without excessive bending of the corrugations. The special joint shown in Fig. 8 was designed with corrugations of unusual depth supported by a cross-frame of extra-heavy pipe, as indicated.

A two-pass vertical condenser having 44,000 sq.ft. of surface serves each of the main units. A single circulating pump has been provided per unit. As in the

case of the exciters the pump has a dual drive consisting of turbine and constant-speed induction motor. When the circulation has once been started, there is little work for the pump in addition to the friction head of the system, owing to the siphonic action. The plan is to use the motor drive during the summer months and the steam turbine during the colder periods of the year, when considerable exhaust steam is required for heating. With the turbine drive there is some opportunity for regulation, so that the circulation of the cooler water can be reduced in accordance with the requirements. Other auxiliaries serving the condenser are a motor-driven condensate pump and hydraulic vacuum pumps to remove the air. Three nozzles are provided per condenser, although only two will be required in service at any one time. A motor-driven hurling water pump circulates the water through the nozzles.

At the river bank, 200 ft. from the plant, the screenhouse and two sets of tunnels have been built for the first half of the plant, although screens have been installed only for the first two units with a spare to provide for cleaning or breakdown periods. Vertical screens, 45 ft. between centers and 6 ft. 6 in. wide, have been used. They are protected by a floating timber boom to keep out ice and logs, and the usual trash racks. Intake and discharge tunnels measuring 7x8 ft. in section and superimposed for the greater part of their length, are to serve each two-unit section of the plant. These tunnels parallel the outside of the turbine room, and cross-tunnels of 5x6-ft. section lead to each unit.

How Frazil Ice Is Kept Off the Trash Racks

One of the features of the system is a recirculation scheme to keep the frazil ice off the trash racks. From the nearest point of the condenser discharge tunnel a 42-in. bell and spigot pipe carries some of the discharge water to a cored passage in the concrete wall of the screenhouse. Through diffusers the warm water is admitted near the bottom of each section of the rack. Valves control the flow according to requirements. Past experience has shown that it is necessary to keep the rack only a fraction of a degree above the freezing point to prevent the fine needle-like frazil ice from adhering to the surface.

The switchhouse, which has been arranged parallel to and facing the turbine room, contains six floors. Starting from the bottom, the first is a cable vault, the second contains the feeder reactors, potential transformers and automatic starters for the exciters. The third floor is devoted to control conduits, the fourth to the oil circuit breakers, the fifth to the main and auxiliary 13,200-volt buses and the sixth to the bus reactors.

For local distribution, 13,000-volt lines go out of the station underground. Connection to the 110,000-volt overhead transmission line previously referred to is made through step-up transformers in the outdoor substation. There are three high-tension 18,750-kva. transformers connected closed delta on the low side and star connected on the high side, with a spare arranged so that it can replace quickly any one of the transformers in service. The arrangement consists of a transfer bus with three double-throw switches, an unusual feature being the location of this bus inside the switchhouse.

Instead of placing the control room with an outlook over the turbine room, it has been placed along the outside wall of the switchhouse so that plenty of daylight comes in along the entire side and one end of the building and through a skylight covering the entire room. The operator is kept fully informed by means of an intercommunicating telephone system throughout the plant and a signal system between generating units and the benchboard.

While the switchhouse is to be located along the entire length of the turbine room, the control house will be shorter and centered on the ultimate plant. The building, which has been completed already for two sections, or four generating units, has three floors, the first containing the station auxiliary transformers and 4,000-volt transformers for local distribution, the second the 4,000-volt feeder regulators on the lighting circuits and the third the control boards. The latter consist of double benchboards arranged facing each other on either side of a central aisle, one side being devoted to the generators and transformers and the other to the feeder circuits. All controls have been placed on the bench; the instruments on the vertical panels and at the back are the vertical boards for the relays and watt-hour meters. Following out the general plan, all conduits to these boards are open and accessible.

ANALYSIS OF CONSTRUCTION COSTS BY PERCENTAGES

	Per Cent
Land	1.92
Construction equipment	1.14
Buildings, foundations, stack supports, etc.	23.24
Screenhouse and tunnels	3.42
Turbines and supports	13.68
Condensing equipment	4.10
Boilers, settings, superheaters and soot blowers	10.25
Stokers and fans	3.80
Stacks, flues and uptakes	1.33
Piping system	6.84
Coal-and ash-handling system	1.60
Heaters, pumps, evaporators, water weighers, etc.	1.94
Electrical equipment	9.36
Miscellaneous equipment	1.06
Engineering and supervision, insurance and interest during construction	14.82
Trackage, roads, bridges, etc.	1.50

Auxiliary Power Supply

Auxiliary station power aggregating 3,500 kw. in connected load is taken off the main bus and through either one of two 3,750-kva. banks of transformers delivered to the 2,300-volt auxiliary bus employing truck-type panels located on the third floor of the control room. Motors above 75 hp. take energy directly at the bus voltage, but for the smaller motors station transformers intervene to reduce the service to 220 volts.

For station distribution, three 2,300- to 220-volt substations have been provided—one under the control room, one on the first floor of the switchhouse and one in the boiler room, each being placed as near as possible to the motors served. In each case the control is at the motor itself. For the three groups of transformers there is an emergency bank as a reserve and duplicate feeders to the motors, one from the operating bank and the other from the spare. Duplication here was considered important as the shutdown of an auxiliary would mean that the main unit would go out of service.

The plant was designed and constructed by the Byllesby Engineering & Management Corp., of which H. W. Fuller is vice-president and chief engineer; F. H. Lane, manager of engineering and construction; H. Boyd Brydon, mechanical engineer, and R. M. Stanley, electrical engineer. On the operating end James Colvin is superintendent of generation.

PRINCIPAL EQUIPMENT OF HIGH BRIDGE STATION OF NORTHERN STATES POWER CO.

GENERAL

Location of plant	On Mississippi River, near High Bridge, St. Paul, Minn.
Capacity present building, kw	60,000
Ultimate capacity, kw	240,000
Boiler-room dimensions, ft.-in.	93–6x166–2
Distance boiler-room floor to basement floor, ft.	34
Height from boiler-room floor to roof girders, ft.	48
Width of firing aisle, ft.	21
Ratio boiler-heating surface to floor area	9.6 to 1
Turbine-room dimensions, ft., in.	62x166–2
Ratio kilowatt rating to floor area	5.8 to 1
Distance basement floor to turbine op. floor, ft.	25
Height turbine-room floor to roof trusses, ft., in.	46–6

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Number of boilers	8
Type	Cross-drum, vert. baffled, 3 passes
Steam drum, one, outside diameter, in.	60
Tubes, 756	4 in., No. 9 gage, 21 ft. long
Steam-making surface, sq.ft.	18,750
Working pressure, lb. gage	300
Superheat, deg. F.	250
Steam temperature, deg. F.	672
Superheaters, Foster	Power Specialty Co.
Radiant superheater, sq.ft.	210
Convection superheater, sq.ft.	4,028
Furnace volume, cu.ft.	5,300
Furnace volume per 10. sq.ft. boiler-heating surface, cu.ft.	2.8

STOKERS

Manufacturer, 4 Frederick	Combustion Eng. Corp.
Manufacturer, 4	Westinghouse Elec. & Mfg. Co.
Type	Underfeed, 14-retort, clinker grinders
Stoker drive, multispeed induction motor, 2 per stoker, hp.	12
Clinker-grinder drive, two induction motors per unit, hp.	5
Silent chain drives for stokers and clinker-grinders	Link Belt Co.
Motor control	Manual, drum-type controller

FORCED DRAFT FANS

Manufacturer	Buffalo Forge Co.
Number installed	8
Type	Double width turbo conoidal
Capacity, cu.ft. per min.	94,000
Speed, r.p.m.	856
Drive, induction motors, 150 hp., 2,300 volts	Westinghouse Elec. & Mfg. Co.
Motor control	Manual, drum-type controller

STACK

Manufacturer	Minneapolis Steel & Mchy. Co.
Type	Self-supporting steel
Diameter at top, inside concrete lining, ft.-in.	17–3
Height above boiler-room floor, ft.	250

BOILER-FEED PUMPS

Manufacturer	Worthington Pump & Mach. Corp.
Number	5
Type	Four-stage, double-suction
Capacity, each of 4 pumps, gal. per min.	750
Drive	240 hp., 2,580 r.p.m., Terry turbine
Capacity of test pump, gal. per min.	300
Drive	110 hp., 2,720 r.p.m., Terry turbine
Boiler wash pump, one, gal. per min.	160
Drive, motor, 40 hp., ind., 1,800 r.p.m.	General Electric Co.

FEED-WATER HEATERS AND METERS

Manufacturer of heaters	Worthington Pump & Mach. Corp
Type	Three-section, horizontal, open
Number	2
Capacity, lb. per hr.	400,000
Meters, three, V-notch recording	Bailey Meter Co.
Capacity, each of two, lb. per hr.	400,000
Capacity of test meter, lb. per hr.	200,000
Stage heaters, four	Elliott Co.
Two eleventh-stage	216 sq.ft., 285,000 lb. per hr.
Two fourteenth-stage	800 sq.ft., 285,000 lb. per hr.

EVAPORATOR

Manufacturer, Lillie	Sugar Apparatus Mfg. Co.
Equipment	One double-effect high-pressure evaporator and condenser
Capacity, lb. per hr.	10,000

SERVICE PUMPS

Manufacturer	Worthington Pump & Mach. Corp.
Number and type	Four double-suction, single-stage centr.
Capacity, gal. per min.	1,600
Drive	65 hp., 200 r.p.m., Terry turbine

COAL AND ASH HANDLING

Manufacturer	Link Belt Co.
Apron conveyors, two, 36 in., 170 ft. long.	
Peck carriers, two, 30x30 in., 130 ft. vert. lift, 115 ft. hr. centers, speed 55 ft. per min., capacity 120 tons per hour.	
Crusher, single roll, 30x36 in., motor-driven, 200 tons per hr.	
Belt conveyors, two, 30 in., 175 ft. centers, 120 tons per hr.	Robbins Conveying Belt Co.
Coal valves and spouts, 16 in., 24	Henry Pratt Co.
Coal cars, two, steam-operated dump, 30 cu.yd.	Western Wheel Scraper Co.
Locomotive cranes, two, yard storage	Link Belt Co.
Locomotive, yard use	H. K. Porter Co.
Track scales, 125 ton	Fairbanks, Morse & Co.
Ash gates, air-operated	Allen-Sherman-Hoff Co.
Air compressor	Worthington Pump & Mach. Corp.

TURBO GENERATORS

Manufacturer	General Electric Co.
Number	Two
Turbine, Curtis, stages	17
Steam pressure at throttle, lb. gage	285
Superheat at throttle, deg. F.	250
Generators 3 phase 60 cycle, 13,200 volt, 35,300 kva. 30,000 kw. at 85 per cent power factor.	
Speed, r.p.m.	1,800
Guaranteed water rate:	
Steam conditions, 285 lb. gage pressure, 280 deg. F. superheat. 1 lb. abs. back pressure, no steam bled.	

Load, Kw.	Lb. Steam per Kw.-Hr.
30,000	9.95
27,000	9.60
20,000	9.85
15,000	10.30

Air washer, type V, 85,000 cu.ft. per min.	Spray Eng. Co.
Washer pump, 600 gal. per min., drive 30 hp. motor	Goulds Mfg. Co.

CONDENSERS AND AUXILIARIES

Manufacturer	Worthington Pump & Mach. Corp.
Number	2
Type	Surface, two-pass, vertical
Surface, sq.ft.	44,200
Surface per kilowatt of generator rating, sq.ft.	1.467
Capacity, lb. steam per hr.	330,000
Circulating pump, one per condenser, gal. per min.	41,000
Drive, dual, 300-hp. Terry turbine, 300-kw. 2300-volt, G. E. induction motor.	
Vacuum pump, No. 7 hydraulic, three nozzles per condenser.	
Hurling-water pump, motor driven, 1,600 gal. per min.	
Sand pump, drive 25-hp. motor, 800 gal. per min.	
Hot well pump, one per condenser, 2-stage, Terry turbine drive, 250 gal. per min.	
Auxiliary service pump, makeup to heater, 40 hp. motor, 800 gal. per min.	
Screens, three, revolving, 6 ft. 6 in., 45 ft. centers	Chain Belt Co.
Screen wash pump, one, single-stage, 4 in.	Worthington Pump & Mach. Corp.
Pump drive	75 hp. G. E. ind. motor, 1,750 r.p.m.
Exciters, two, 300 kw	General Electric Co.
Drive, dual, 450 hp. turbine and 2,300 volt ind. motor, 1,200 r.p.m.	

STATION CRANES

Turbine room, traveling, 100-ton, 4-motor	Niles-Bement-Pond Co.
Coal unloading, traveling, 10-ton, 4-motor	Whiting Corp.
Pumproom, traveling, 5-ton, 3-motor	Whiting Corp.
Screenhouse, 8-ton, hand power	Whiting Corp.

MISCELLANEOUS MECHANICAL EQUIPMENT

Oiling system, filters, continuous bypass plan	S. F. Bowser & Co., Inc.
Valves and piping	Crane Company
Piping covering and cork roofing	Smith Totman Co.
Stop and check valves	Edward Valve & Mfg. Co.
Blowoff valves	Edward Valve & Mfg. Co.
Safety valves, Consolidated	Manning, Maxwell & Moore Co., Inc.
Water columns	Babcock & Wilcox Co.
Feed-water regulators, sets	Williams Gauge Co.
Pump governors, b.f. pumps, Mercon	D. H. Skeen & Co.
Pump governors, service pumps	Fisher Governor Co.
Steam traps	Armstrong Machine Works
Heating system, vacuum	Crane Co.
Soot blowers	Diamond Power Spec. Corp.
Freight elevators, one 6,000 lb., one 10,000 lb.	Otis Elevator Co.
Passenger elevators, push-button aut., two 1,000 lb., one 2,000 lb.	Gus Lagerquist & Sons
Water strainers	Elliott Co.
Structural steel fabricated by	Minneapolis Steel & Mach. Co. St. Paul Foundry Co.
Ventilators	Swartwout Co.
Atmoshperic turbine exhaust	Minneapolis Steel & Mach. Co.
Skylights, corrugated wire glass	Sykes Co.
Doors, steel rolling	Kinnear Mfg. Co.
Firedoors	Variety Fire Door Co.
Bilge pumps, five	Yeomans Bros. Co.
Subway grating	Irving Iron Works Co.
Plumbing	Crane Co.

STATION INSTRUMENTS

Steam-flow meters	Bailey Meter Co.
Draft gages, five-pointer	Bailey Meter Co.
Indicating thermometers	Taylor Instrument Co.
Master steam gage	Ashton Valve Co.
Indicating pressure gages	Ashcroft Mfg. Co.
Recording gages, pressure and temp	Bristol Co.
Orsats	Bailey Meter Co.
Condenser leakage instrument	Esterline Angus Co.

ELECTRICAL EQUIPMENT

Benchboard, including meter and relay boards	General Electric Co. Company Constr. Dept.
Instruments	General Electric Co.
Station auxiliary board, truck type	General Electric Co.
Motors, induction, above 75 hp. 2,300 volt, below .75 hp. 220 volt	General Electric & Westinghouse
Transformers, four, 18,750 kva., 13,200/110,000 volt	General Electric Co.
Transformers, seven, 1,250 kva., 13,200/2300 volt, Westinghouse Elec. & Mfg. Co.	
Oil circuit breakers, 13,200-volt, 3,000, 2,000 and 600 amp., truck type	General Electric Co.
Oil circuit breakers, motor circuits	Westinghouse and General Electric Co.
Disconnecting switches and insulators	Delta Star Electric Co.
Bus reactors, generator, 1,042 kva., 1,365 amp., 762 volt, 10 per cent reactive drop.	General Electric Co.
Feeder reactors, 80 kva., 350 amp., 229 volt, 3 per cent reactive drop	General Electric Co.
Potential transformers	General Electric Co.
Current transformers	General Electric Co.
Storage battery, for remote control	Electric Storage Battery Co.

Possible Methods of Reheating Steam

By J. R. McDERMET
Research Engineer, Elliott Company

REGENERATIVE heating, and stage resuperheating during the course of the steam expansion in the turbine, have provided new standards for the judgment of performance. The resultant economies are such that the practice of regenerative heating, at least, will endure, while the process of resuperheating can apparently be supplanted only by a method of continuously withdrawing moisture from the sections of the turbine where the steam is saturated. No proved method has been proposed for mechanically removing moisture from the steam in the course of expansion. At the same time, the methods of resuperheating are not yet developed to the point of established practice. It is the purpose of this article, therefore, to review and suggest methods by which the advantages of resuperheating may be gained by alternate methods.

UNLIKE the regenerative or stage-bleeding cycle, the reheating cycle is still on trial. The time is ripe for a broad consideration of all possible methods of reheating, with a view to improving on conventional methods. This article points out the possibilities and disadvantages of such mediums of heat transfer as radiant energy, heated gas, oil, melted salt mixtures, organic liquids and mercury vapor.

Inter-stage reheating with moderate or large-sized turbine units introduces the following difficulties:

On account of the small net gain due to improvement of turbine and cycle efficiencies with resuperheat, the friction pressure loss in the resuperheating equipment external to the turbine must be kept very small. This introduces the necessity of large pipe lines, leading between the turbine and the reheater.

With such large pipe lines the expansion strains will be formidable, particularly from the viewpoint of turbine distortion.

The resuperheater with its large piping represents a considerable investment. It is not thought, however, that there is any possible alternative that will secure a significant reduction in cost. Alternative methods must therefore be concerned with superior operation, lowered friction losses or greater safety.

On account of the large volumes inclosed in the resuperheating equipment, the storage capacity for steam is large, and this steam with conventional methods of governing is not under governor control. This objection is not fundamental for the reason that alternative methods of governing are possible.

It is to be expected that operating conditions will compel the complication of combined resuperheater and boiler surface, the boiler surface protecting the resuperheater. It would be well if these two processes of generating some steam and superheating a larger and separate quantity could be divorced.

Possible methods of conveying heat to steam for superheating comprise the following on a purely physical basis: Radiant energy; conduction from gases; convection from liquids; condensation of vapor.

The absorption of radiant energy may rise to any conceivable value and reach a final limit on the basis of ability to cool the surfaces with the fluid to be heated rather than to conduct the heat to the surface.

The absorption on the side to which heat is delivered is dependent upon the ability properly to focus the radiant waves and the approach of the surface to black body conditions. The limit may be, therefore, anticipated as the life of incandescent refractories serving as a means of focusing radiant heat, and with commercial materials can be made to exceed the ability of the surface to absorb the heat.

There is a somewhat fanciful possibility at the present stage of the art in locating the resuperheater adjacent to the turbine and as part of the structure, and conducting the heat in the form of radiant energy through fused quartz tubes. The price is, however, so prohibitive that the suggestion has no merit other than novelty. The conductivity of gases heating a surface by conduction can be set within commercial limits of three to six B.t.u. per hour per square foot per degree F.

The conductivity from liquid to gas using the liquid as a medium of heat circulation, can be set from 10 to 50, depending on the velocity of liquid circulation. In any event this method of resuperheating involves a double interchange of heat, first heating the liquid and then transferring the heat to the steam in the process of resuperheating, both processes of which operate at low conductivity.

The conductivity conditions with vapors involve conductivities varying in magnitude from 300 to 800 in commercial applications. The heating and vaporizing of the liquid takes place under low conductivities, but the transfer from liquid to steam takes place under high conductivities. There is a distinct advantage, therefore, in using the heat of vaporization of a liquid. In the vapor-to-vapor transfer of heat in the actual resuperheating process the conductivity of the condensing and reheating surface would undoubtedly be limited on the steam side rather than on the side of the condensing liquid.

Before going into greater detail on the minor subdivisions of these previous classifications, it is worth noting that the demand for materials to resist higher temperature and pressure will undoubtedly be met within a short time. It may be expected that the maximum temperature at which materials will be satisfactory and of commercial cost will be raised from 750 to approximately 950 deg. F. within the space of the next year.

A process of initially superheating steam at low pressure, to a high temperature will require a high temperature gradient over the surface from furnace gases to steam, which in turn will necessitate a cost out of proportion to the benefit derived, or a further increase in satisfactory commercial materials for temperatures above 950 degrees.

It is obviously impractical to attempt a separate reheating cycle with steam at high pressure, since such a pressure for use with commercial sizes of surface will necessitate an intermediate steam pressure at least as high as the initial steam pressure to the high-stage admission of the turbine. The degradation of heat energy in the resuperheating process positively prohibits consideration of this method.

Combination of Gas Engines and Steam Turbines

It is not improbable that future power-plant practice will involve either gas engines or boilers fired with byproduct gas, the major idea being the value of byproduct recovery. Under such conditions a gas-fired reheater in the turbine structure could be considered, since the possibilities of thermal control are available in this method. The fundamental objection is the high exit temperature of the gases from the resuperheater, necessitating the additional complication of cooling them. Commercially, however, the value of byproduct recovery must be sufficient to cover the cost of gasification before the method can become commercially useful.

If the alternative of using a circulating liquid as the vehicle for the transfer of heat quantities is considered, it is to be expected that the conductivities in the heat interchanges, involving the liquid, will range between ten and fifty B.t.u. per square foot per hour per Fahrenheit degree difference. Obviously, the most familiar liquid for circulation is water under high pressure and highly superheated, but as a liquid.

The conductivities will be moderate even at high circulation velocity, and the surface at which heat enters the liquid will probably be limited to convected heating rather than to radiant heating, on account of the limitations of heat removal.

A usable conductivity will undoubtedly require high circulation velocities with the liquid, a consequent high power cost, and also a very costly circulating pump for the purpose.

Sulphur, Oils, Salts and Mercury

A satisfactory material on its face value would undoubtedly be molten sulphur, but water or water vapor leaking into the liquid sulphur or sulphur vapor would produce a violently corrosive mixture which no known commercial material could withstand.

Satisfactory oil mixtures have been developed for almost any usable commercial temperature in the tempering of steel, and it is therefore possible to buy a circulating oil that will meet the temperature specifications. It is, however, necessary to employ an oil mixture, usually a mineral and an animal oil, to secure the proper temperature characteristics, particularly flash point.

These oils decompose under high temperatures and produce a sludge, and while there is a vast difference in the quality of such oils, the objection is common to all of them to some degree. This sludging will produce overheating on the surfaces through which the heat is initially transmitted, stoppage of pipe lines conveying the oil, and also high cost of circulating medium.

Mixtures of various salts may be prepared with almost any desired melting point and with no tendency to attack the metal. Little information is available on the heat conductivity of such mixtures.

Another possible medium is mercury. The pressure-temperature function of mercury is low, resulting in the use of relatively light materials of construction. The system necessarily must be tight on account of the high cost of the mercury. On the other hand, it is a material that can be readily secured at a price that can be at least roughly foretold.

While the pressure relations in the actual resuperheating would undoubtedly prevent leakage of mercury vapor into the steam, the mixing resulting from such leakage would not produce a harmful product.

The heat capacity of mercury from the viewpoint of the specific heat of the liquid is high, resulting in better inherent regulation in the system.

The use of mercury as an indirect heating medium is already established in the chemical art, and successful installations can be used for guidance in design. There is, however, the possibility of conflicting patents, which must be faced with this method of circulation of heat more than any other.

The mercury has a high density both as a liquid and a vapor, and the conducting pipes would be small.

Direct Injection of Mercury Vapor a Possibility

There is further the possibility of injection of mercury vapor into steam, since the two liquids separate perfectly when condensed. It is also possible that the amount of mercury vapor accumulating in the steam condenser would not be sufficient to affect the operation of the turbine. The partial-vapor-pressure relationship of mercury and water at low temperatures has not, however, been carefully investigated, and it is not possible at the present stage of research to compute the operation of condensers with steam as a cooling medium, when condensing mercury vapor, where the process is of the direct mixing type.

The present art of building steam surface condensers will not permit the presence of liquid mercury on the tube surface, on account of the danger of amalgamation and season cracking of the tubes. It is to be emphasized that the mercury poisoning hazard has been overestimated.

While organic liquids having high boiling points and low vapor pressures are known, none of them has the high heat content of the liquid which is characteristic of mercury, and their heats of vaporization are generally not available. These liquids are of a complex molecular constitution, and are almost invariably flammable and poisonous.

Use of Accumulator with Resuperheating

A World Power Conference suggestion worthy of careful consideration is the use of a Ruths accumulator taking steam from the high-pressure turbine elements, and storing and delivering it to a conventional superheating element for resuperheating and passing through the low-pressure stages of the turbine as the load requirements of the units might vary.

Such a combination would involve a high-pressure section of the turbine, taking steam from the boilers at high pressure and exhausting into the accumulator at substantially saturated temperature, and a low-pressure section of the turbine taking steam from the accumulator, passing it through the superheater, and discharging into a conventional condenser.

The water cycle from the viewpoint of the high-pressure turbine element would involve the circulation of feed water from the large storage space in the accumulator to boiler, while the cycle from the viewpoint of the low-pressure element would involve the

pumping of condensate through stage heaters to the accumulator. The accumulator would therefore serve the double purpose of storage and stage extraction heater.

While, in theory, the regenerative cycle is applicable to the entire temperature range of the steam expansion, investment costs practically limit its application to the lower-pressure section.

Such a scheme would involve turbine governing in the high-pressure element on the basis of accumulator pressure, and could be so regulated as to involve only the steam pressure on the governor without any direct throttling governor intervening. It is the thought in making this suggestion that such turbine units at the present stage of the art would be for essential base-load operation only, in which the load variations could be accurately forecasted and the boiler pressure regulated accordingly.

Under this scheme the high-pressure section of the turbine would be controlled only by an emergency governor to avoid overspeed.

Such a scheme would obviate to a great extent the problem of throttling with high-pressure steam; would involve a considerable heat storage in the accumulator, and would cause the accumulator to function also as a stage heater. The low-pressure section of the turbine would obviously be conventional, but under the control of a primary speed governor.

One thought in making this suggestion is the economy to be gained in high-pressure boiler construction. It is to be expected that the high-pressure boiler fed with high-grade feed water might conveniently use small tubes for considerations of strength. It is also to be expected that, with decreasing water storage, boiler drums could be made much smaller.

The accumulator under such a condition would provide a reserve of hot-water storage sufficient to provide for the boilers for a considerable time, long enough in fact to permit complete control of the fires. The boilers under temporary load loss on the unit could be discharged into the accumulators until the fires were brought under control, with only a relatively slight degradation of heat and no loss of water.

The accumulator should at least discharge into superheaters for resuperheating the steam, and simultaneously, a section of it might be direct heated for boiler purposes. In other words, a boiler could be connected into the accumulator circuit of sufficient capacity to protect resuperheating elements.

Fundamentally, the turbine operation would not be changed, nor would the economy of the cycle under steady load, if the accumulator were connected below the saturation point on the expansion line. Boiler-feed auxiliaries would have to be reliable and in duplicate. The accumulator would not be costly except from the viewpoint of the space occupied.

Filtering Transformer Oil in the Field

BY FRED C. DEWEESE*

FILTERING and drying transformer oil is a job that must be done in the right manner if the desired results are to be obtained. It is also essential to have the proper equipment for testing and drying the oil, otherwise the condition of the oil at the end of a run is largely guesswork. While this article primarily describes the use of the filter press, there are centrifugal types of oil purifier available which may be used for the same purpose as the filter press. These dry, or, in other words, separate the moisture or other undesirable matter from the transformer oil by means of centrifugal force.

The equipment necessary for this purpose comprises a filter press, electric oven for drying the blotters and an oil-testing transformer. The testing transformer, for work in the field, should be of the small portable type, the low-voltage side being 110 volts, in order that it may be connected to a standard lighting socket. The high-voltage side should have a range of 15,000 to 33,000 volts inclusive.

This testing transformer should be taken on the job, as it has been the experience of the writer that taking samples of oil from a transformer to a laboratory to be tested, is unsatisfactory. Even if the container, bottle or whatever it may be, is perfectly dry and is handled in the most careful manner, the receptacle of the testing apparatus may contain some moisture on its walls, thus giving an erroneous result by causing the oil to break down at a lower voltage than the actual condition should show. In the field, it is an easy matter to run several tests, and the tests should be repeated until each one breaks down at about the same voltage, when the result obtained may be considered reasonably accurate.

Before the filtering process is begun, a sample of oil should be taken from the transformer, and it is usually necessary to take it from the bottom. The first sample, of a pint or more, should be drawn off and emptied, as this will give the oil a chance to wash out any particles of dirt, etc., that may be lodged in the pipe and valve. Oil taken from the bottom of a transformer that has been idle for some time, will usually break down at a voltage below what is considered a standard value, as there is no circulation of the oil and the moisture will settle to the bottom. This is not always the case with transformers that are in operation, as only the water that is not held in suspension will settle to the bottom of the transformer. If the sample taken from the bottom of the transformer shows a lot of moisture by test, or even if water is visible in the oil, this is not an indication that the oil is not in good condition, for it is only the water that is held in suspension that lowers the dielectric strength.

BREAKDOWN VOLTAGE OF THE OIL

While the type of testing transformer previously mentioned will not show the exact condition of the oil, it will indicate when the oil is safe for operating practice. As an example, suppose that the oil stands up at 19,500 volts, but breaks down at 24,000. This shows that it has a breakdown voltage somewhere between these limits. If the oil breaks down at 28,000 volts but stands up at 24,000, this indicates that it is good. However, in this connection, it is necessary that one test alone is not relied on to tell the story, but at least three samples, or three tests from the same sample,

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should be made. If they are properly made and all show a breakdown of better than 24,000 volts, it is reasonably sure that the oil is good, and this is all the men in the field care to know.

Order of Procedure

The first step to be taken, after arriving on the job, is to connect up the electric drying oven and fill it with blotters, being careful to allow sufficient clearance between them so that the warm air from the heating element can circulate properly. The drying of the blotters should continue for approximately an hour, before any of them are used.

While the blotters are drying, the pipe connections can be made from the filter press to the transformer, and if the transformer is of a modern type, it will not be necessary to interrupt the service for doing this work. The connections should be made so that the oil is taken from the bottom of the transformer, forced through the blotters and returned into the top of the transformer. The oil should be circulated until the filtering is completed. If the oil is low in the transformer, it will be necessary to pour some new oil in the filter-press tank, thus allowing it to be pumped into the transformer.

The size of press most desirable for field work is the 7-in., which has a capacity of approximately 400 gal. per hour. Before starting the press, be sure that the screen is clean, for any appreciable amount of dirt on the screen will greatly retard the flow of oil.

After everything is ready, the blotters are placed in the press, which will take 112, four in a place. After a few minutes' run, another test of the oil should be made, at which its actual condition may be determined. The amount of dirt and moisture in the oil will govern the intervals between the time of changing the blotters. The more dirt and moisture the oftener they will have to be changed.

If the oil is dirty, the pressure gage will indicate the condition of the blotters. As the dirt accumulates on the surface of the blotter, the pressure will rise. It should not be allowed to go above 110 lb. However, if the oil contains moisture only and is otherwise clean, the pressure gage will not indicate when the blotters should be changed.

Change One-Fourth of the Blotters at a Time

In changing the blotters, change one-fourth of them at one time. There are four blotters on each side of the spacer in each chamber, and the one that the pressure comes against should be changed; that is, the two inside ones should be taken out, the other three brought toward the chamber and the new blotter slipped in behind them. Or, if there is doubt about which ones to change, take out the dirtiest ones and put the new ones on the opposite side of the three left in from the one taken out. If this method is followed, each blotter will be used approximately the same length of time, and their maximum efficiency will be obtained.

The breakdown voltage of transformer oil is based on the voltage across a 0.1-in. gap between one-inch disk electrodes. There is usually a gage accompanying the test set for setting the electrodes.

In making the test, it is essential to see that there are no air bubbles on the face of either electrode, as this will cause the oil to puncture, and sometimes the arc will continue, thus showing inaccurate result. It is a good plan just before making the test, to run the gage between the electrodes; this will wipe off any bubble that may be on the surface.

There is usually a book of instructions accompanying the test set, and these instructions should be followed closely. One thing to be careful about, if the instrument is not grounded, is not to remain closer than about two feet from the transformer while the test is being made. Especially should this be the case if a test is being made at 33,000 volts, as I have known the testing instrument to arc over a distance of about twelve inches.

What To Expect from a Water-Treating Plant*

By A. S. Behrman

The purpose of water treatment in raw-water ice plants is so well understood that it would be unnecessary repetition to say more than a few words on this phase of the subject. The object of water softening is to make better ice and more ice. Some waters are so good, or they have impurities of such kind, that treatment of the water is not justified. Some waters are so bad that no treatment except distillation will make them suitable for the manufacture of ice.

But most waters can be treated to advantage; and when such a water is treated, the substances are removed that would cause deposit and discoloration in the ice, as well as a tendency toward cracking and shattering. As a result the ice made from the treated water is clear and free from deposit or color. A great economy in operation is that core-pumpings are reduced or eliminated altogether. Lower brine temperatures can be carried safely without cracking.

Adding the Lime

The essence of water softening for raw-water ice is treatment with lime. And right here the engineer building a lime-soda water softener has his most important and difficult job, because the lime-feeding equipment is the heart of the softener. Lime dissolves so slightly in water that it is not practical to feed it even as a saturated water, which, by the way, is ordinary lime water. The early softeners did feed the lime water and were so inaccurate and generally unsatisfactory that they were abandoned. So now the lime is fed in suspension, that is, a mixture of lime and water, or "milk of lime."

There are two problems that must be solved in the accurate feeding of milk of lime. One is to keep the mixture so well stirred up that every ounce contains just as much lime as every other ounce. The other problem is to feed this constant-strength mixture in proportion to the water being treated. It is frequently taken for granted that any of the ordinary agitating devices are good enough to keep the lime mixture in a state of uniform suspension. This is far from being the case. Even with very vigorous horizontal agitation, for instance, the lime particles have a tendency to stratify and settle out. As a consequence the upper part of the mixture is weak; and water treated with this is undertreated, while the water treated with the lower part of the mixture will be overtreated. In either case, of course, the result will be poor ice.

*Extract of paper read before the National Association of Practical Refrigerating Engineers, New Orleans, Nov. 13, 1924.

So the two requirements for really satisfactory chemical feed are, first, that lime mixture be absolutely uniform, and second, that this uniform mixture be fed in strictly accurate proportion to the water being treated. It is easy to mix a spoonful of lime thoroughly in a bucket of water, but it is very difficult to mix a bucket of lime in a thousand-gallon tank of water. For this reason the modern lime softener is nearly always of the continuous type; that is, a small quantity of chemical is added continuously to a small quantity of water.

The necessity of uniformity of water treatment is emphasized because if there is one industry in which uniformity of treatment is necessary, it is in the ice industry. In treating water for boiler feed, it doesn't make so much difference if some of the water is a little undertreated and some a little overtreated, as long as the sum total of the water in the boiler averages up to a properly treated water. But in ice making it is different. The 300 to 400 lb. in one can cannot give or take any chemical from the can next to it. There is no chance to average up. Every can must, so to speak, stand not only on its own bottom, but on its own treatment.

A pound of lime will do a certain amount of work. If we put one pound or ten pounds, or a hundred pounds of lime in the lime tank of a softener that treats water uniformly, the lime will be distributed uniformly throughout the water being treated. That is the job of the softener. It is the engineer's job to put in the softener the amount of lime that will give a properly treated water. If, for example, the water being treated in a softener requires ten units of lime, and if ten units are used, a uniformly and properly treated water and all good ice will be obtained. But if only six or eight units of lime be used, an improperly treated water and all bad ice will result.

If, on the other hand, the softener is one that does not treat water uniformly, the correct charge of ten units of lime may give some good ice, but certainly will give some ice not so good and some bad ice. And even an incorrect charge of six units or eight units will probably give a few blocks of good ice because the variation in the treatment will just happen to balance the underdose or overdose of chemical for a few minutes of the entire run.

Results Should Be Uniform

A plant that makes only an occasional block of good ice might almost as well never make one. But by some strange streak in human nature, some operators seem perfectly satisfied to see just a few good blocks in a lot of bad ones. As far as the water softener is concerned, and other things being equal, it is better to have the ice uniformly bad than some bad and some good; because if the ice was uniformly bad, one would know that the plant could turn out all good ice if the softener was operated properly.

In general, do not expect water treatment to make up for faulty operating conditions. One of the first things that come to one's mind is "red ice." In at least three cases in which the water softener was blamed for red, analysis showed that the red was caused by iron, but the analysis also showed that there was no iron in the softened water. Investigation of operating conditions in the ice plant itself revealed that when the ice was pulled and lowered into the dip tanks, rusty brine splashed into the cans and some remained there because the cans were not completely drained.

Another frequent source of red ice is found in rusty forecoolers and pipe lines. Still another cause of red ice, and an important one, is leaky cans. I have counted as high as 90 per cent of leaky cans in a plant. And yet we find that even in cases like these, the water softener is sometimes held responsible for the red ice.

Water treatment cannot take the place of air agitation, although frequently less agitation will be sufficient when using treated water. The purpose of air agitation is to create currents of water. These currents of water wash the surface of the ice as it freezes and carry off the tiny particles of mineral matter and gas bubbles that would otherwise freeze out in the ice and make it white.

We have given up hope of getting away from some form of agitation under normal plant operating conditions. It has been suggested that agitation could be done away with if the air was removed from the water. But we found that the dissolved air is only one part of the problem. The other part is dissolved minerals. Even reboiled distilled water, free from air and having only a very few grains per gallon of salts in it, will give white ice.

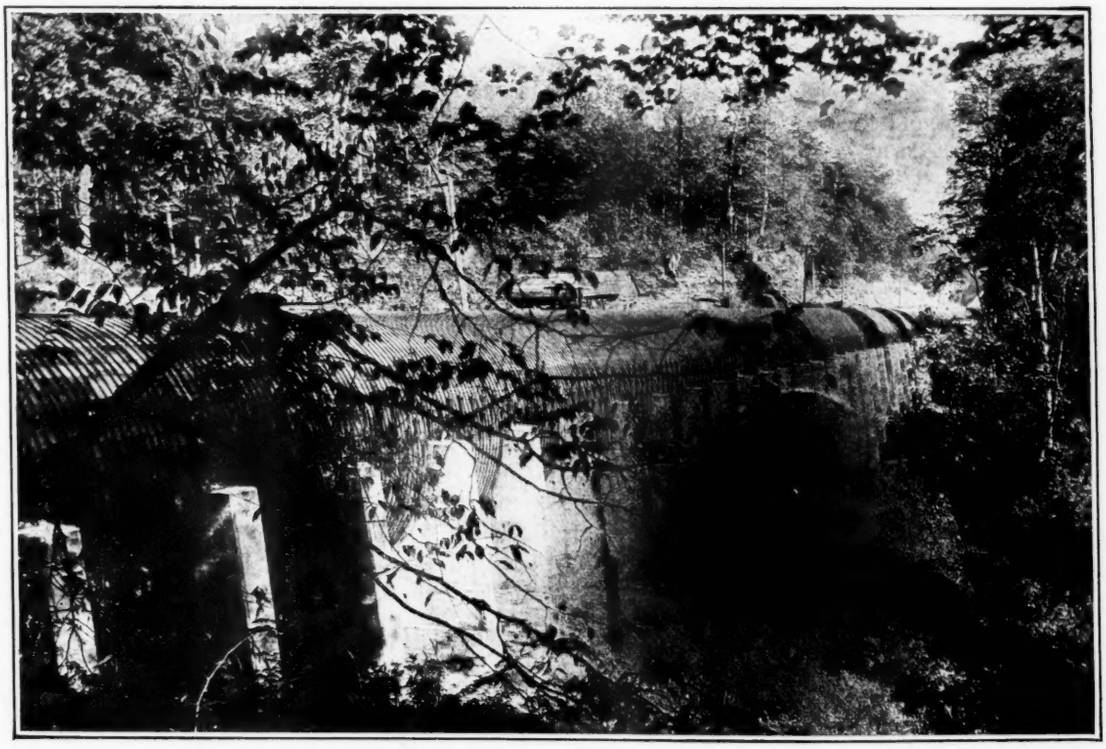
Cause of Cracked Ice

Cracking and shattering are also sometimes laid at the door of water softening, whereas the ice made from the softened water is so much more solid and firm than ice made from the raw water that, as a rule, lower brine temperatures can be carried without cracking. One is much more likely to find the trouble in bulging cans, particularly when using high brine levels, in uneven temperatures, in poor core-washing and filling, or in a lot of other things that have not the remotest connection with the water treatment.

Finally, if one has the misfortune to use water that contains common salt or other impurities that no treatment except distillation will remove, do not hold the softener responsible for the limitations on freezing conditions that result. Occasionally a complaint is made that brine temperatures around 10 to 12 deg. F. cannot be used without getting white shells and white bottoms. In nearly every case this is due to the soluble salts that cannot be removed by treatment. With waters of this sort the freezing is so quick at these low temperatures that all the salts cannot get out quick enough, and the white shell or bottom is the result.

To sum up the whole situation, the engineer has a right to expect and to demand from a water softener that it deliver uniformly treated water as long as it is operated properly. There its job stops. Beyond this is the jurisdiction and responsibility of the engineer.

With the attention directed at the mercury-vapor turbine of W. L. R. Emmet, a story has arisen concerning a vessel, "The Mercury" by name, which employed mercury in its boilers and which is said to have made successful voyages a number of years ago. It appears that the process employed in this vessel was to generate steam by spraying water on the surface of heated mercury. Just what advantage was to be gained by the process is not evident, unless it was the more efficient transfer of heat from the flue gases to the mercury than would have been possible with water.



Wood-stave pipe supported in reinforced-concrete cradles

Improper Backfill Causes Failure of Wood-Stave Pipe Lines

By BYRON E. WHITE
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With respect to strength a wood-stave pipe is similar to a barrel without heads, both against internal pressure and external loading. With increasing diameter it is therefore necessary to use staves of greater and greater thickness. There is small strength against crushing from concentrated loads on top with any practicable thickness of staves. Hence, where roadways cross lines of wood-stave pipe or much loading exists or is anticipated, provision should always be made to carry the entire load external to the pipe by means of bridges or otherwise.

The relatively small strength against crushing and the relative thinness and flexibility of wood pipe cause it to flatten out of round unless means are taken to hold it to a true circle.

For this purpose it is customary to lay wood pipe in saddles or cradles, fitted to the circumference of the pipe and usually extending up nearly to the horizontal diameter. When this is done, there is very little deformation when the pipe is emptied and no load superimposed on it. In the headpiece is shown a 12-ft. wood-stave pipe supported in reinforced concrete cradles.

The strength to resist internal pressure and the stability against crushing are supplied by the bands with which the pipe is surrounded. The maximum pressure which the pipe can withstand is determined by the closeness with which the bands can be spaced and the diameter of the rods and by the crushing strength of the wood under the bands. It is customary to make bands in two parts, one approximately surrounding the lower and the other or top band, surrounding the top half of the pipe. These are connected on either side of the pipe by means of malleable-iron shoes. The bands are generally so arranged that the lower half is provided with several inches of threads, on which nuts are screwed down against seats on the malleable-iron shoes. These are then tightened or cinched until the staves are brought closely enough together so that little or no leakage occurs between them.

Accidents sometimes occur when filling with water or when placing backfill around wood-stave pipes.

Short Sheetpiling Used to Prevent Wash Due to Leakage

In one case a large wood pipe was installed for a long distance in a cut through very fine sand. It was realized that considerable wash would probably take place due to the leakage through the staves during the tightening process. Damage from this cause was avoided by driving short vertical sheetpiling across the bottom of the trench and a short distance up the sides, at intervals of about 100 ft. prior to the pipe's erection, which effectively prevented any serious wash at that time.

An attempt was made after the pipe was filled with water to place the backfill around and over the pipe by hydraulic sluicing from one side. This was carried on

at such a rapid rate that the backfill, which naturally rose much higher on one side of the pipe than the other, pushed the pipe laterally out of line, pulling the horizontal joints sufficiently to cause considerable leakage. This leakage found its way down the trench to a point beyond where the wood pipe connected to steel, undermined a blowoff valve which was so connected that its weight allowed it to break off, and necessitated the shutting down and emptying of the pipe line.

The hydraulic fill was in such a plastic condition that when the pipe was emptied, it collapsed from the top, necessitating the renewal of several hundred feet. Figs. 1 and 2 are two views of the pipe after it collapsed. The remedy for this situation would naturally be to carry on hydraulic backfill slowly, from both sides of the pipe at once, keeping the backfill at about the same elevation on each side.

An instance occurred within the writer's knowledge of a 42-in. wire-wound pipe, which was laid and backfilled in the winter time. Large lumps of frozen earth were placed in the backfill, and when this thawed, the pipe lost its lateral support and entirely collapsed for a considerable distance, necessitating its complete rebuilding.

A similar instance of the collapse of a 60-in. wood-stave siphon has been reported. After a long section of pipe had been backfilled up to about the horizontal center line, a heavy snow fell, which was not removed before continuing the backfill. This later thawed and, the horizontal support being impaired, the pipe collapsed.

Limits of Backfill Over Pipe

Except for very small sizes of pipe, say three feet in diameter or less, it is not good practice to backfill more than two or three feet of loose earth over the top of the pipe. The small sizes have sufficient strength and are generally utilized under sufficient water pressure to sustain almost any depth of backfill. This is particularly true of wire-wound machine-made pipe.

As a result of an accident in which a wood pipe collapsed when partly backfilled, a study was made which indicated that pipes built with staves of ordinary thickness cannot stand up when empty, or not under pressure, under a backfill having a depth of more than one to two feet over the top of the pipe. If the depth of backfill is to be greater than this, it is necessary either to increase the thickness of the staves or to encase the pipe in concrete of sufficient strength to sustain the load.

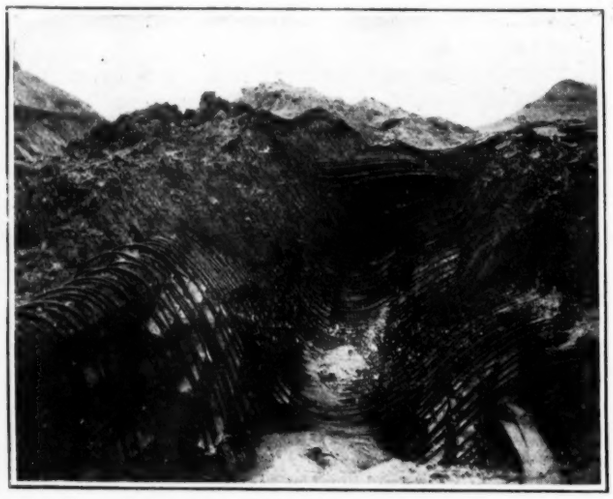

Fig. 1—Collapse of 12-ft. pipe line installed in fine sand

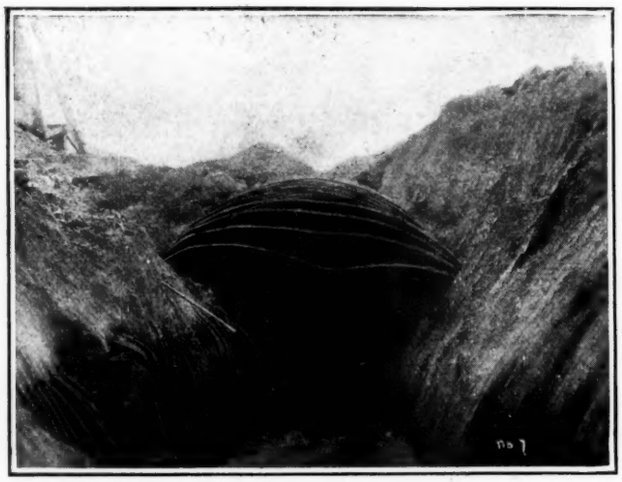

Fig. 2—Another view of the pipe line, Fig. 2

Where considerable backfill is to be placed over the medium- and large-sized pipes it is necessary to provide against crushing by a thorough bracing of the pipe, at least up to the horizontal center line, by means of cradles or otherwise. It is dangerous to rely on loose earth backfill alone because leaks may occur which may wash away portions of the material, leaving the pipe without lateral support.

A common difficulty with pipes laid untreated underground is that after a period of years, the pipe becomes so soaked that it easily reacts to the pressure or weight within and on top of it and has a tendency to bulge upward at the sills supporting it. This also occurs wherever stones, boulders or other objects underneath the pipe become exposed by washing away of the surrounding earth. It would seem advisable to take precautions to see that the pipe is securely supported for about one-quarter of its circumference at the bottom so as to avoid this difficulty, which sometimes causes serious leaks.

In the installation of wood pipes a practical point to be given consideration is that of leaving sufficient space between the horizontal diameter of the pipe and any walls, obstructions or adjacent structures to allow of working the ratchet wrenches with which the bands are cinched up. While it is possible to work with a minimum clearance of 18 in., it is much better to make this clearance 24 in. or greater. It is also advisable to leave not less than an 18-in. and preferably a 24-in. space all around the pipe, including the bottom, for inspection and ease of application of preservative treatment after the pipe has been built.

A case occurred in the writer's experience where a wood-stave pipe collapsed when emptied, due to the removal of the supporting fill on one side of the pipe without removing the earth from the top. Such a pipe is perfectly safe against collapse under such conditions so long as it has a sufficient head of water in it to resist the weight of the overlying earth. Such a condition should be carefully avoided in cases where adjacent construction work or repairs make it necessary to remove the earth alongside a section of pipe more than a very few feet in length. If it becomes necessary to do so, the top half of the pipe should be completely uncovered.

Selecting Boiler Feed Pumps

By C. L. HUBBARD
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Principles of boiler feed pumps and means of calculating the total required head were discussed in last week's issue. Characteristics and the selection of feed pumps are here taken up.

THE standard pump for boiler feeding has been the direct-acting steam pump, widely used in plants of small and medium size, say below 500 hp. Above this, to 1,000 or 1,500 hp. it is giving way considerably to the centrifugal type; while in plants larger than these the centrifugal pump has become practically the standard.

While both the simplex and duplex types of steam pumps are used for boiler feeding, the latter is preferable on account of producing a continuous flow of water. With regard to pistons and plungers in the water end, it is usually found somewhat difficult to keep the piston tightly packed when discharging against pressures exceeding 150 lb. per sq.in., and it is common practice to employ through plungers, Fig. 1, for 200 lb. and above. The advantage with the latter type is that the packing is stationary and may be kept in adjustment more easily. For low pressures the piston type is less expensive than the plunger pump. The advantages of the plunger pump, other than the one already mentioned, are the ability to detect leaks, and repack without dismantling the pump in certain forms which are designed for this special purpose.

Among the advantages of the direct-acting steam pump for boiler feeding are its low first cost, simplicity,

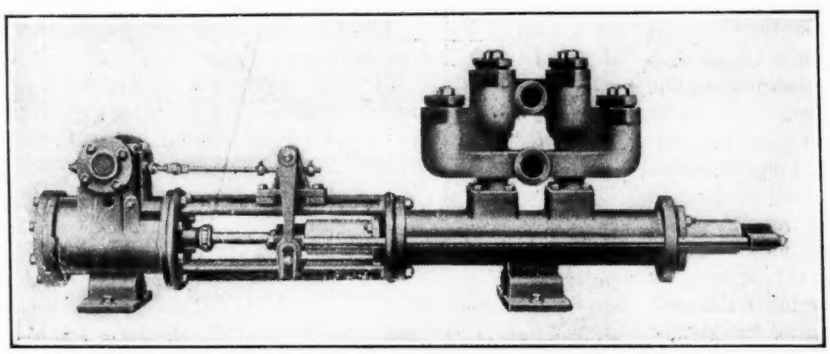


Fig. 1—Outside-packed water plunger frequently used for high pressures

low maintenance, and ease of speed regulation to meet changing load requirements on the boilers.

The principal disadvantage is the large steam consumption, which varies from 100 to 200 lb. per indicated horsepower per hour according to size and speed. These figures apply to pumps receiving good care and will be considerably exceeded by those in poor condition.

In general, the number of strokes per minute should be limited to about 50 in the smaller sizes and 40 in the larger. Piston speed is not of so much importance as was formerly supposed, because the maximum strain occurs during reversal of stroke and is not especially affected by the length of stroke or speed of piston, except so far as the momentum is a factor at the time of reversal. The rating of a pump should be in gallons or pounds of water per unit of time, under normal working conditions.

While the power pump, in which the plungers are driven by a crank and connecting rod, is employed for boiler feeding to some extent, its use is limited because

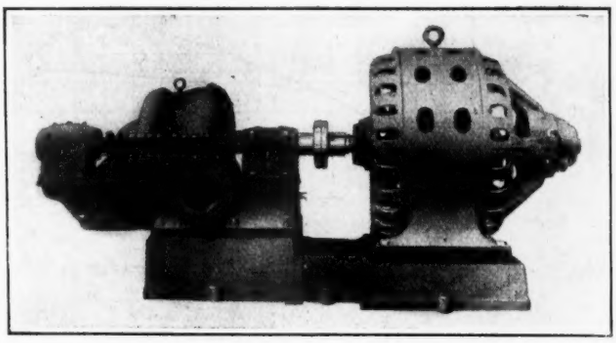


Fig. 2—Motor-driven boiler feed pump

the direct-acting steam, and centrifugal types, are superior in a majority of cases when all points are considered. The most common type is that constructed with three vertical single-acting cylinders, with the cranks set 120 deg. apart, an arrangement that gives a fairly steady flow. Pumps of this type are commonly driven by an electric motor or steam engine through a belt or silent chain, although geared in some cases.

Centrifugal pumps are in general use for boiler feeding in plants of 500 hp. and over, and are almost universally employed in those of 1,000 to 1,500 hp. and above. The advantages of this type of pump are its simplicity and absence of valves, and the fact that its delivery is continuous. The principal disadvantage is the difficulty of securing proper regulation at constant speed without interfering with the pressure characteristics and efficiency. While a steam turbine drive makes speed variation possible, the tendency in large plants is to employ electric drive, as in Fig. 2, for as many of the auxiliary pumps as possible. A combination that works out quite satisfactorily in cases of this kind is to employ motor-driven pumps for the steady load and take care of the variation with turbine-driven units.

Owing to the comparatively high pressures encountered in boiler feeding, multi-stage turbine pumps are commonly employed, allowing one stage for approximately each 50 to 60 lb. pressure, but sometimes 100 lb. per stage.

Having considered the more important characteristics of the different types of pumps used for boiler feeding, let us now see how these bear upon the selection of an outfit for various locations and conditions of operation.

Although mention has been made of the large steam consumption of direct-acting feed pumps, it should be remembered that in a well-designed and carefully operated plant of medium size, this should not represent more than 1 to 3 per cent of the fuel burned.

In considering the ultimate economy of the boiler-feeding apparatus, we should look further than the efficiency of the pump, taken as an independent machine, and consider it in relation to the other component parts of the plant. In non-condensing plants, where the exhaust from the main engine is not sufficient for all heating purposes, the exhaust from a steam pump can be used toward making up the deficiency, in which case it simply serves as a pressure-reducing valve, and power for pumping is generated at an extremely low cost, thus making it the most economical type to employ. On the other hand, if there is surplus exhaust from the prime mover, so that that from the pump cannot be utilized, then a power- or motor-driven pump will require less coal.

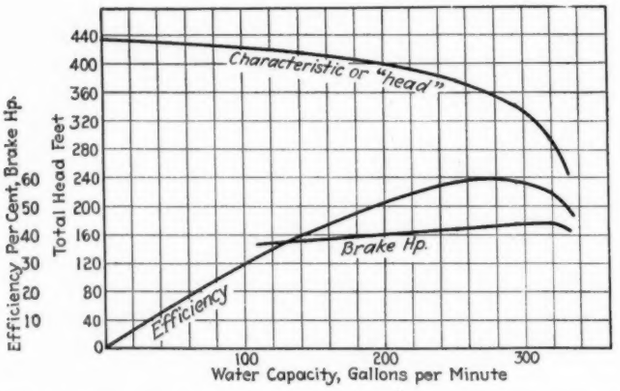


Fig. 3—Curves for a 2-stage centrifugal pump rated at 275 g.p.m., 350 ft. head and 3,000 r.p.m.

One Steam-Driven Pump for Reliability

In combined power and heating plants, such as frequently occur in the industries, office buildings, public institutions, etc., both of these conditions are likely to occur, there being insufficient exhaust for all heating purposes during the winter, and a large surplus during the summer, when the main heating system is shut down. In such cases it is often advantageous to install both steam-driven and power- or motor-driven pumps, the former for winter use and the latter for summer, when the main engine is exhausting outboard. With this arrangement two steam pumps and one power pump could be installed, the former serving as a stand-by unit during the summer.

In general, it is good practice always to have one steam-driven feed pump in every plant capable of doing the entire work, as then it will always be possible to feed the boilers while pressure is on regardless of anything that might happen to the prime mover or generator. This stand-by pump may be either of the direct-acting type or driven by a steam turbine, so long as it is a self-contained unit. In condensing plants it is usually possible to use all or at least part of the exhaust from the pumps in heating the feed water. If only a portion can be utilized in this way, part of the service may be by motor-driven pumps and the remainder by a steam-driven unit, which is also a convenience in the matter of regulation.

If power pumps are used, driven by electric motors, the latter should be of the inclosed or semi-inclosed types when located in places where they are exposed to dust. They should be of a design capable of sufficient speed variation, by means of a regulating rheostat, to meet the requirements of efficient boiler-feed service. With a constant-speed motor on a reciprocating feed pump, it is necessary to secure regulation by means of a bypass valve which admits more or less water to the boiler as required. Such an arrangement is very wasteful of power because the pump must work against full boiler pressure at all times regardless of the quantity of feed supplied.

No Excessive Pressure from Centrifugal Pump

As previously stated, the centrifugal pump is particularly well adapted to continuous service in plants of over 500 hp. where the requirements are 50 gal. per min. or over. This type of pump has no valves to wear out and maintains practically the same efficiency throughout its life. The principle upon which it operates is such that it cannot develop an excessive pressure at normal speed, even though the discharge pipe is entirely closed, the water in this case being simply churned around within the casing. This makes it possible to regulate the quantity of water delivered to the boiler, to a certain extent, by throttling, without any considerable loss of efficiency with a properly designed impeller.

With a turbine drive the speed may be varied for regulation within limits that do not reduce the pressure head below that necessary to force the water into the boiler, which, in general, should exceed the boiler pressure by about 25 lb. per sq.in.

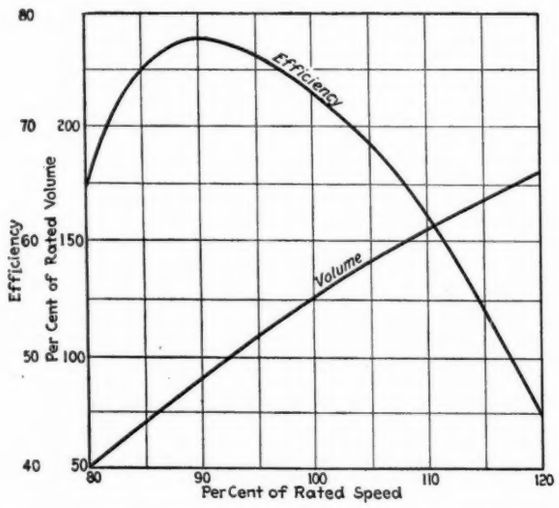


Fig. 4—Centrifugal pump discharging against constant head at variable speed

While the delivery of a centrifugal pump varies directly as the speed, the head developed varies as the square of the speed, so that the range for regulating the quantity of water delivered by changes in speed is naturally confined to somewhat narrow limits. However, special governors have been designed, actuated by the pressure in the pump discharge, which control the turbine speed automatically and make it possible to obtain a considerable range of capacity while maintaining a pressure head that is very nearly constant.

The same general laws regarding change of speed of course hold with a variable-speed motor drive as well as with a turbine.

The steam consumption of a turbine-driven pump, of the capacity employed for boiler feeding in plants of medium size, will ordinarily run from 40 to 45 lb. per b.hp. per hour.

While pump sizes and speed for different capacities are commonly taken from trade catalogs or builders' tables, it is often convenient to have a table of general data at hand for making approximations. Table I gives working data for a variety of direct-acting duplex pumps, allowing a volumetric efficiency of 80 per cent.

TABLE I—OUTPUT OF DIRECT-ACTING DUPLEX PUMPS, WITH AN 80 PER CENT VOLUMETRIC EFFICIENCY

Size Dia. Steam Cylinder × Water Cylinder × Stroke, All in Inches	Strokes per Minute	Pounds of Water Pumped per Hour
3 × 2 × 4	50	2,174
4½ × 3 × 4	50	4,890
5¼ × 3½ × 5	45	7,487
6 × 4 × 6	45	11,737
7 × 4½ × 7	40	15,405
7 × 5 × 7	40	19,018
7 × 4½ × 10	40	22,006
7 × 5 × 10	40	27,168
8 × 5 × 12	40	32,602
10 × 6 × 12	40	46,946

For simplex pumps, divide the quantities in the last column by 2 for the same cylinder dimensions and length of stroke. Table II gives similar data for triplex pumps.

TABLE II—OUTPUT OF TRIPLEX POWER PUMPS

Size Dia. of Cylinders × Stroke, Both in Inches	Revolutions per Minute	Pounds of Water Pumped per Hour*
2 × 3	32	1,830
2½ × 4	31	3,665
3 × 4	32	5,489
4 × 4	29	9,162
4 × 6	28	12,820
5½ × 6	25	21,975
5½ × 8	25	29,300
7 × 8	24	43,956
8 × 8	24	61,050

* The quantities in the last column are for the single-acting type; for double-acting pumps multiply these by 1.9. Intermediate capacities between those given in the table may be obtained by variations of speed.

If there were no leakage past the valves or piston of a reciprocating pump, the volume of water delivered in a given time would equal the piston displacement, and most pumps are rated upon this basis in manufacturers' catalogs. The displacement or theoretical quantity of water pumped per minute, neglecting leakage, is given by the following equations:

$$C = \frac{L \times A \times N}{1{,}728}, \quad W = L \times A \times N \times 0.036,$$

$$G = \frac{L \times AN}{231}$$

in which

C = Cubic feet per minute;
W = Pounds per minute;
G = Gallons per minute;
L = Length of stroke in inches;
A = Area of piston or plunger in square inches;
N = Number of strokes per minute.

As a matter of fact, there is a varying amount of valve leakage and piston "slip" which reduces the volume of water actually delivered to a quantity somewhat below that of the piston displacement. The ratio of the volume delivered to the piston displacement is called the volumetric efficiency, and while this may run from 0.95 to 0.98 in new pumps, it is commonly taken as 0.85 to 0.90 for those that have been in service for some time. Hence, when estimating the capacity of a pump from a catalog rating, deduct from 10 to 15 per cent to cover slip and leakage.

The size of centrifugal pump for a given capacity will vary with the type, speed, head pumped against, etc., and no very accurate table for general use can be given. The following applies to multi-stage boiler-feed pumps of a well known make, and will be found useful in making approximations. The capacity range in the last column varies with the head pumped against.

TABLE III—CAPACITY RANGE OF MULTI-STAGE CENTRIFUGAL BOILER FEED PUMPS

Diameter of Discharge Pipe, in Inches	Revolutions per Minute	Pounds of Water Pumped per Hour According to Head
2	3,500	25,000 to 60,000
3	3,100	70,000 to 85,000
4	2,500	100,000 to 150,000
5	2,200	175,000 to 250,000

Most of the general data given thus far apply to all types of pumps, except the items of displacement and volumetric efficiency, which are concerned with piston or plunger pumps only. Data relating to centrifugal

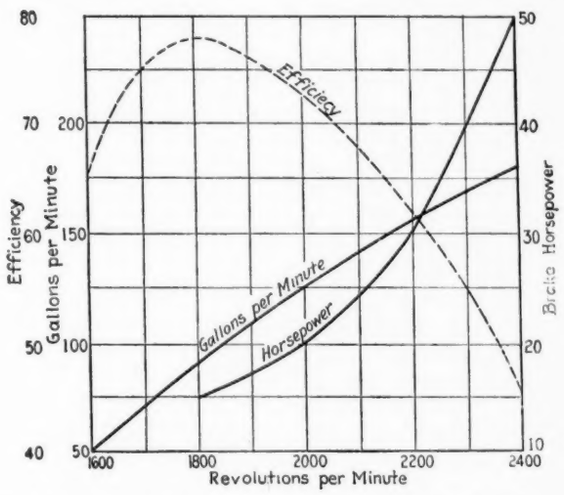


Fig. 5—Indicates great increase of power at high speed, for 100-g.p.m. 2,000-r.p.m. pump, for 125-lb. boiler

pumps are obtained from tests, usually run at constant speed, and curves are plotted showing the relation of capacity, head produced and power required. These curves are known collectively as the "characteristics" of the pump. While running at constant speed the delivery pipe is throttled so as to vary the rate of delivery, which in turn changes the head. The characteristics of a boiler-feed pump designed to deliver 275 gal. per minute against 350 ft. head while running at 3,000 r.p.m. is shown in Fig. 3. The curve representing the head is commonly designated as the characteristic on the diagram and varies considerably in form, depending upon the design of the impeller.

For boiler feeding a fairly flat characteristic is desirable, as it is necessary to vary the rate of delivery by throttling, and this should not affect the head at any considerable extent within a reasonable range of regulation. Also, it is important that the efficiency curve be such that it does not vary greatly within the ordinary capacity range. In Fig. 3, in varying the delivery from 250 to 150 gal. per min., the head rises from 378 to 412 ft. and the efficiency falls from 58 to 42 per cent.

In certain cases, especially in plants of comparatively small and medium size, the feed pump is driven either by a steam turbine or a variable-speed motor, and regulation is secured by speed variation at practically constant head, within certain limits. The curves in

Fig. 4 have been plotted from a more complete set found in Marks' "Mechanical Engineers' Handbook," which represent the average results that may be expected from a high-speed high-head pump of good design. The curves show the relation of speed, volume delivered and efficiency for speeds ranging from 80 to 120 per cent of the rated speed for which the pump is designed, while maintaining a constant pressure head equal to 80 per cent of the rated head.

As these curves give percentages of rated results, they are fairly well applicable to any pump of this general type in which the various ratings are known. The curves in Fig. 5 have been plotted from this for a feed pump rated at 100 gal. per min., at 2,000 r.p.m. against a pressure head of 190 lb. per sq.in. This is suitable for feeding a boiler carrying 125 lb., as it is customary to allow a margin of about 25 lb. above that carried on the boiler, therefore calling for a discharge pressure of 125 + 25 = 150 lb. in the present case.

As the curves in Figs. 4 and 5 are for the pump which must operate at 80 per cent of its rated head, the latter must be 150 ÷ 0.8 = 190 lb., in order to develop an actual discharge pressure of 150 lb. As the rated head falls when the pump is operated below the rated speed, it is necessary to base all results as to speed, volume, etc., on a percentage of the rated head which will be sufficient for all feeding requirements (150 lb. per sq.in. in the present case), with the pump running at the lowest desired speed, which is 1,600 r.p.m. The curve for brake horsepower has been plotted, using efficiencies taken from Fig. 5 for the different speeds. When variable-speed driving equipment is used, suitable safety governors must be provided to prevent excessive speeding up should a drop in pressure occur in the discharge pipe, due to losing the suction or from any other cause.

Air Coolers for Turbo-Generators

By F. W. RABE*

AIR filters and air washers are at present extensively used to clean the cooling air for large electric generators. The detrimental effects of dust-laden air, when used for cooling the generator windings, are well known, and the fire hazard, augmented by the forced supply of air to the generator armature and windings, cannot be overlooked.

During the last few years closed surface cooling systems have been developed for recooling the air for turbo-generators. In these systems the cooling medium, usually air, is forced through a surface cooler where the air gives up its heat to condensate or raw water or both. The air flows in a closed circuit through the generator and cooler and, because of the limited oxygen content of the system, the fire hazard is greatly diminished. If nitrogen instead of air were used, the cooling effect would be practically the same and the fire hazard would be eliminated. The use of carbon dioxide, which does not support combustion and whose cooling effect is about 20 per cent better than that of air, has also been considered; however, the greater density and tenacity of this gas increases the friction losses. Helium seems to be a desirable cooling medium for generators as it causes low friction losses and has about 20 per cent better cooling effect than air.

The cooling elements of the air coolers on the market today are usually made of Muntz or Admirality metal tubes embraced by a number of copper or brass fins. These tubes are either circular or elliptical. When the elliptical tubes are so arranged that their major axes are in line with the direction of air flow, a much greater surface is exposed between the tubes and the air, as compared with tubes of circular cross-section, and smooth flow results without sacrificing the slight whirling of the air necessary to obtain good heat transmission.

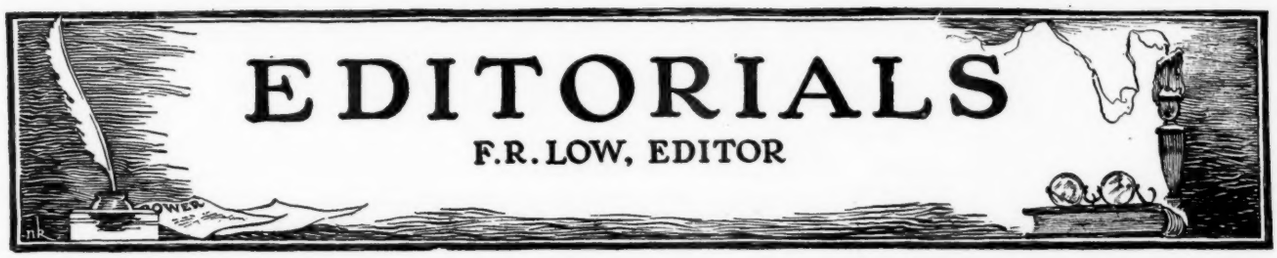
The rate of heat transfer is more affected by the air velocity than by the water velocity through the tubes, and a heat transfer of 12 B.t.u. per sq.ft. per deg. F. per hour has been obtained with shallow coolers and a high air velocity. Where turbine condensate is used as cooling water and it absorbs all the heat given to the cooling air by the generator, the thermal gain is apparent. In plants operating on the regenerative cycle there is only a slight thermal saving obtained by the use of generator air coolers as compared with obtaining the same temperature by extracting steam from regions of lower pressure. However, generator air coolers are usually installed for other reasons than to increase the thermal efficiency of a plant.

If the condensate from the main condenser is used to cool the air, it is generally advisable to arrange the air cooler for raw-water circulation or use two coolers in series, forcing the air through the sections operating on the turbine condensate and then through other sections using raw water. At heavy loads and in cold weather it may not be necessary to use the raw water cooler. According to the A.I.E.E. standardization rules the air must be cooled to 104 deg. F. before it re-enters the generator.

Besides eliminating the spray device maintenance, keeping the machine clean and minimizing the generator fire risk, it is possible to have the temperature of the cooling air independent of the condition of the outside air. The temperatures of the circulated air are then affected only by the quantity and temperature of the cooling water flowing through the air cooler. Generators are necessarily designed for the highest summer temperatures and, when a closed air cooling system is used, they may be operated at considerably higher rating during the summer months without overheating. It is also of interest to note that when the air is cooled in this way, the undesirable noise accompanying the air flow in and out of the generator is eliminated to a large degree.

The development of the supply of electric power and light in Japan has gone forward with unusual rapidity during the last 10 or 15 years, and at present Japan is one of the best served countries, electrically, in the world, according to *Commerce Reports*. As an indication of the extent of this development, official statistics, recently published, show that there was operating in Japan on May 31, 1922, a total of 1,715,261 kw. At that time there were under construction new plants with a total capacity of 1,343,348 kilowatts.

*Mechanical engineer, New Haven, Conn.



Large Turbines Operate Three-Quarters of the Time

THE reliability of large prime movers, as evidenced by detailed reports of eighty-seven units, summed up by the Prime Movers Committee of the N.E.L.A. for the year 1923, as recently made public, has not quite reached the point where it can be regarded as absolutely satisfactory. An abstract of this report appears in this issue. Of the total operating time demanded of these particular units, they failed to respond to the extent of about one-fifteenth of this interval, or to be exact, seven and seven-tenths per cent. This, however, is certainly not a large margin of default, and the fact that there was a reserve period of greater length when the units could have been utilized but were not, tends to throw the balance in the other direction. In fact, the reserve hours while ready for duty represented nearly one-seventh of the demanded operating period, or about fourteen per cent, as opposed to the seven and seven-tenths when actual conditions prevented suitable response. Actual operation was about three-fourths of the total time.

Other encouraging factors are that five per cent more service was demanded than during the previous year, and that this demand was met more satisfactorily to the extent of one and one-half per cent. Prospects for the future are excellent from the record in general, but to what extent the recent changes in plant design will introduce hazard has yet to be determined.

Nearly half of the turbine maintenance is required for general inspection and overhauling, while a comparatively insignificant amount is charged against vibration, and a comparatively little against the wheels or spindles. Condenser maintenance, as an impediment to operation, is one-half as great as the turbine repairs and twice that of the generator. Cleaning tubes has become a large factor on account of the low vacuum and requirements of operating economy. In all probability more will be demanded of the condenser in the future, as there will be fewer shutdown periods due to other causes, in which condenser maintenance may be carried on without being charged against the condenser.

Isolated Plant a Field for High Pressures

PRESSURES around three hundred and fifty to four hundred pounds are now practically standard for new central stations, although several plants are about to go into commission at pressures around six hundred pounds and at least one new station will give twelve-hundred-pound units a trial.

There appears to be no corresponding growth in pressures for isolated plants. It is only reasonable that the isolated plants, most of which are relatively small, should sit tight for a year or two until their big brothers have demonstrated the practical value (or otherwise) of various innovations now under trial.

But whatever psychology may have to say in the matter, there seems to be no good economic or engineering reason why average isolated-plant pressures should ultimately be lower than the corresponding central-station pressures. This statement may seem strange in view of the fact that the size and load of the central station generally warrants greater refinements in the interests of economy, but two important factors must be remembered. The first is that central stations almost invariably operate condensing and with vacua better than twenty-eight inches, often better than twenty-nine inches. The second is that the majority of isolated plants operate non-condensing and that even where they carry a vacuum, steam is generally bled for process and heating.

Now the back pressure has a highly important effect upon the economic initial pressure. An initial pressure not worth consideration when operating with twenty-nine-inch vacuum may become of interest with twenty-five-inch vacuum and may be highly profitable when the back pressure reaches five pounds gage.

Many central-station operators seem to feel that the net gains obtainable by raising the initial pressure above six hundred pounds are not worth going after at the present time. Much larger relative gains are available with high back pressures, so the day may well come when the highest steam pressures will be found, not in central stations, but in non-condensing insolated plants having a high ratio of power demand to process-steam demand.

Compound Compression in the Refrigerating Plant

RECENTLY, there has been a flood of arguments among refrigerating engineers on the merits and demerits of compound compression. While there have been several well-conducted tests from which sound conclusions may be drawn, most of the data used consist of results of operation in plants where compound compressors have replaced single-stage machines. Unfortunately, in all or almost all such instances the replacement did not stop at the compressor, but included condensers, prime movers, ice tanks and other equipment. Just how much of the saving can properly be assigned to the compound machine cannot be gaged, and the engineer who makes a change on such grounds alone is following an illogical procedure. But this should not be taken to mean that the compound machine has no advantages.

The jacket cooling of a compressor is notoriously inefficient, and compression is almost adiabatic. The interposition of an intercooler between a low- and a high-pressure stage does serve to bring the temperature down from that registered by the low-pressure dis-

charge temperature. However, the suction temperature cannot be reached without some liquefaction. The temperature of the high-pressure suction must always be somewhat above the saturation temperature at the intercooler pressure, which means that with a saturated low-pressure suction vapor, the difference between the low-pressure suction and the lowest high-pressure suction is considerable. This is the reason why all the advantages of the compound air compressor, where it is possible to intercool to the low-pressure suction temperature, cannot be secured in the ammonia compressor. Of course cooling to the saturation temperature corresponding to the intercooler pressure calls for the use of ammonia as the cooling medium, but the advantage more than compensates for the expense of recompressing this extra ammonia, so much so that water intercooling alone is hardly justified.

The claim that compounding reduces re-expansion losses is not always borne out by results. The compound machine as usually built is a high-speed unit and has a greater clearance volume than the slower-speed single-stage machine. The saving in re-expansion through compounding is largely, if not entirely, offset by the loss due to the greater clearance volumes.

A Late Awakening

COMBUSTION control of boilers is almost as old as the steam boiler, yet it is only within the last few years that it has received the attention that it warrants. This is somewhat difficult to account for, since the boiler plant is the place where the economy of the power station can be most affected during regular operation. On the power-house end economical operation is very much a matter of maintenance. The manner of controlling the plant has comparatively small effect on the efficiency of the station.

This is not the case in the boiler room. The equipment may be maintained in the best of condition, but the combustion efficiency may be low. Furthermore, the combustion efficiency may be at the highest for a given set of conditions and in a short time may be radically changed. Therefore, it is desirable that some means be provided to adjust the combustion process automatically so that the best efficiency will be maintained for each load condition. The fact that so little attention has been given to the control of the part of the station equipment that can be so radically affected in a short time if not controlled, and so much to the part that is least affected, is somewhat paradoxical.

Centralizing the control on the prime movers, their auxiliaries and electric generators, provides convenience of operation and reliability. Centralizing the control of the boiler plant, where it can be at all times under the direction of a high-class combustion engineer, makes for operating convenience, reliability and economy. By the manipulation of the prime movers to obtain the most efficient loading, the economy of the plant can be affected to a degree, but this is small compared with what may be accomplished by proper control of the combustion process in the boiler furnaces. Furthermore, there may be worked out in advance for the guidance of the power-house operator a schedule that under normal operating conditions will show the most economical number of units and their loading to have on the system. Such a schedule for the boiler room is only a small part of the story; the relation of fuel volume to air in the furnace must be maintained to give proper combustion if high efficiency is to be obtained. This is a factor that not only changes with the load on the boiler, but is influenced by many other conditions, some of which are indeterminate quantities that must be compensated for in the control system.

If present indications are a criterion, power-plant engineers are awakening to the possibilities of maintaining high economy in the boiler plant by proper control of combustion, and a number of plants that represent advance practice have installed or are installing complete combustion-control systems. In fact, few important plants are being laid down in which such systems are not considered if they are not installed.

An Opportunity

A REALIZATION that no progressive engineering society can be sufficient unto itself has been responsible for the growing practice in many localities of holding occasional joint meetings on matters of mutual interest.

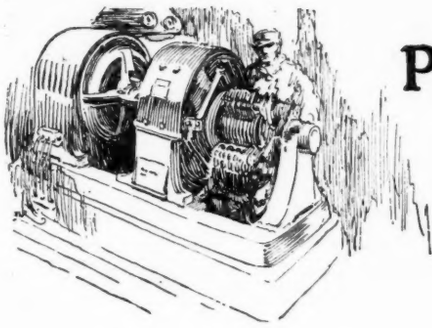
Extending this idea beyond the confines of the professional engineering societies, and predicating his remarks with the observation that the professional and the operating engineers have much to offer one another, Dr. W. F. Durand, president of the A.S.M.E. in addressing the New York N.A.S.E. members last week, graciously extended an invitation to the latter to attend and participate in the power meetings of the Society and its Metropolitan section.

The professional engineer is concerned largely with the design and construction of the equipment that the operating engineer must use. Therefore, a sympathetic understanding of the problems involved and mutual helpfulness is most essential to the attainment of maximum performance.

During the last few years the power sessions of the Society have assumed first importance, due to the many ramifications in design and the rapid advances in power-plant practice. While most of the problems involved have been initiated by those concerned with large plants, the deductions in many cases are also applicable to improvement of the smaller, or industrial, power plant. Here is an oportunity for the operating man of the industrial plant to profit by the discussions at these meetings and in turn, by contributing to such discussions, to direct more attention to the problems involved in his type of plant.

It is sometimes difficult to draw the line between the professional and the operating engineer; indeed, many prominent N.A.S.E. members are also members of the A.S.M.E. However, any imaginary barrier that may have existed between the professional society and the rank and file of the operating men has been removed by Doctor Durand's invitation. It is now up to the local engineers to show their serious appreciation of this opportunity to both give and receive service.

One of the chief difficulties in connection with the use of high-pressure steam (five hundred pounds and over) is the apparent necessity of reheating it. Leading the steam back to the boiler for reheating has, in the opinion of many engineers certain disadvantages. If reheating is not avoided entirely by satisfactory removal of moisture as it forms in the turbine, it seems likely that separately fired heaters or reheating by hot fluids may come into favor for such work. Whether this will become necessary will be determined by the experience of several plants now going into operation.



Practical Ideas *from* Practical Men

Handling Large Piston Rings

Considerable difficulty in entering the pistons of a large engine was experienced by the erector, due to the stiffness of the piston rings causing them to retard the progress of the piston. This difficulty was overcome by using a hoop of $\frac{1}{8}$x1-in. band iron equal in length to the circumference of the cylinder, which had a small right-angle piece welded to each end. A hole was drilled in each piece to take a $\frac{3}{8}$-in. bolt. The band was put around the ring nearest the cylinder and the bolt tightened, drawing the ring down flush with the surface of the piston.

Advancing the piston into the cylinder pushed this hoop back until the ring was well within the cylinders, when it was removed and placed around the next ring of the piston. This device was retained at the plant where the engine had been set up and has proved to be a valuable tool on every occasion when it has been necessary to remove the piston from the cylinder of the engine.

SIDNEY K. EASTWOOD.

Pittsburgh, Pa.

What Caused the Exciter To Be Overloaded?

It occurred to me that probably some readers of *Power* might be interested in an experience I had upon assuming the duties of chief electrician of a sugar factory.

Two years previous to my taking charge the company had installed an engine-driven generator with belted exciter. The unit was tried for a short interval before the operating season began and was found to be in good order, but, after it had been in continuous operation for a few weeks, sparking developed at the brushes. In a day or so this had become so bad that the unit had to be shut down. Upon examination the commutator was found to be badly burnt at four points, equally spaced around the commutator. The mica was cut down, the commutator resurfaced and the machine put back into operation.

A few weeks later the sparking recurred. An expert was called from the factory, and he at once assumed that the armature was shorted or open, so he tried resetting the brushes, changing their angle, testing the coils and the lines to the switchboard. He also tested the armature for open circuit, but none was found. Finally, the exciter was sent to the factory and repaired. The machine was again tested out under a few days' run, and the company concluded that the trouble had been removed. When the machine was again put into regular operation, the old trouble developed.

When I assumed my duties in the spring, I was immediately informed of the trouble, and after making some inquiries, I began looking elsewhere for the trouble. One of the first things done was to draw new wires in the underground conduit, both to the slip rings and to the exciter. However, upon testing out the machine it was found that no improvement had been made. The exciter appeared to be very much overloaded, and I also noticed that a much wider belt was being used to drive it than for another exciter of considerably greater capacity.

The wires from the switchboard to the exciter and slip rings were in the same conduit, a tee being provided close to the machine, one branch carrying the three wires to the exciter and the other branch the leads to the slip rings. Thinking that the source of our trouble was probably in the connections to the machines, we removed the slip-ring leads from the conduit and hung them, temporarily, overhead. This removed the trouble entirely. Later, the wires to the slip rings were put in conduit. I suppose we would have obtained the same results by placing the line underground, but it meant tearing up the concrete floor.

What effect these two sets of wires in the same conduit had on the operation of the machine, I am not sure, but it apparently caused the exciter to be loaded beyond its capacity, causing excessive sparking of the brushes on the commutator. Probably some reader of *Power* can explain this unusual condition.

Paulding, Ohio. PIERRE T. WILLIT.

A Few Remarks About Boiler Settings

The efficiency of a steam boiler is influenced largely by the setting. Therefore the term efficiency means the efficiency of both the boiler and the setting, and consequently it is necessary to obtain a setting as nearly perfect as possible.

Boiler settings are almost universally made of brick, and firebricks are used for the inside courses of the setting. The brick should be of first quality, and special care should be exercised in the selection of firebrick containing high plasticity and a high fusion point and a low element of expansion. The red brick should be of good hard quality and uniform size.

A boiler setting just completed should first be air dried by keeping the damper and ashpit doors open to permit a free circulation of air through the setting; this should be continued for several days. Later, a more thorough drying can be accomplished by keeping a slow wood fire in the furnace for a few days until the walls are thoroughly dried out.

Mortar for laying the red brick should consist of 1 part portland cement, 3 parts of lime and 16 parts of clean sharp sand. It is considered good practice to use not less than $2\frac{1}{2}$ bushels of lime per thousand brick. Care should be taken to have all joints thoroughly filled with mortar. The firebricks should be

dipped in a thin fireclay batter and should be rubbed into place and then tapped with a wooden mallet until brick actually touches brick. Fireclay is not a binder, but is merely used to fill the voids between the bricks. With the exception of arches, the firebrick and red brick should be laid together and the firebrick should be tied in place by means of header courses every fifth course.

Furnace arches should be not less than 9 in. thick and should consist of either firebrick or special arch blocks. Wedge brick are frequently used in making arches, but it is often necessary to use both straight and wedge brick to obtain a desired radius. The middle or key course of an arch should consist of wedge bricks closely fitted. The joints in the arch should be broken, and all brick should fit neatly from top to bottom against the adjoining brick. Good arches require almost perfect brick, and the coefficient of expansion of arch brick should be very low.

When the brickwork has sufficiently advanced, the tie rods for the buckstays should be put into place, and on completion of the brickwork they should be bolted in place and the nuts drawn up tight, after which the nuts should be slightly loosened until the setting has dried out sufficiently to warrant their tightening again. Care should be taken that no gas passages or channels exist which might short-circuit the gas between the boiler walls and the baffles of the boiler.

All doors for cleaning and soot blowing should be carefully set in the walls and anchored to them, making sure that no air leaks exist around the doors. All cleaning doors should have arches the entire thickness of the walls sprung across them.

The tops of drums or shells should be insulated with the common red brick or plastic material of about 2 in. thickness. When brick are used, they should be laid in lime mortar with joints open at the upper edge, and after all bricks are in place the joints should be filled in with cement mortar, then a layer of concrete ½ in. thick should cover the entire surface.

Albany, N. Y. ALBERT SMITH.

How Safety Device Was Installed in Drive of Traveling Screens

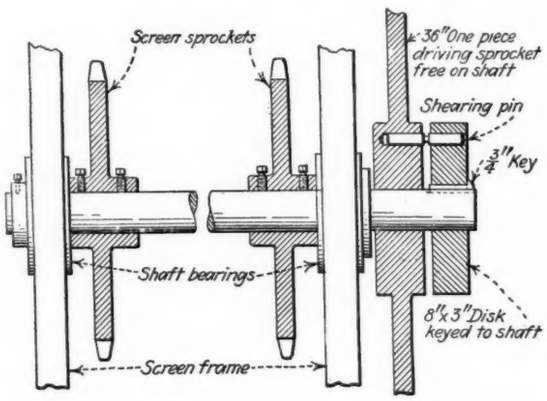
In the operation of our plant we had considerable trouble and expense with the traveling screens on the circulating water intake owing to mud settling around them when standing still.

The screens are motor driven with a speed reduction between the motor and the driving shaft of the screen of 600 to 1. As no special safety device was provided to protect the screen in the event of its becoming wedged fast with mud or other obstruction, the driving shafts were frequently twisted one-quarter turn and the driving sprockets broken. The sprocket chains were supposed to be weak enough to part should any extraordinary strain be encountered. However, as the chains did not provide a safety device for the screen, we decided to take care of this in another way.

Special sprocket disks instead of sprocket wheels, having a hub diameter of eight inches, were obtained and new shafts six inches longer than the former ones were installed in the driving sprockets of the screen. Steel disks 8 in. in diameter and 3 in. thick were keyed to one end of the shafts close to the sprocket disks, as shown in the illustration. A hole for the shearing pin one inch in diameter was drilled clear through the eight-inch disks and three inches into the hub of the chain sprocket, at a point 3¼ in. from the center.

A shearing pin 1 in. in diameter with a central groove ⅜ in. wide cut to a diameter of ⅞ in. was used as a driving pin between the chain sprocket and the disk. A collar was placed on the other end of the shaft to prevent end play. This device has prevented all damage to shafts and sprockets since it was installed and the maintenance cost has been cut practically to nil.

During the month of June we had several periods of high water, carrying a large percentage of mud and a



Shearing pin is provided between chain sprocket and driving disk

number of shearing pins were broken. Had we not installed this device, it is more than likely the plant would have had to shut down three or four times while installing new sprockets and shafts, entailing considerable loss to our customers and ourselves.

Logan, W. Va. E. GEORGE.

Obsolete Examination Questions

In studying my engineering books I find that even in the latest editions frequent reference is made to the old-style ball-and-lever safety valve. It still seems to be the fashion for the writers of license examination books to dwell at length on the old-style valve. The United States Federal examinations still contain questions on this style of valve, and we all know that only in rare cases is it allowed to be used. What we need is education along the lines of spring-loaded valves and their use and abuse.

Why should a candidate for an engineer's license, either marine or stationary, be expected to waste a lot of his time learning about the old-style ball-and-lever safety valve when it is obsolete? He would do far better to devote his time to the present order of things and study the spring-loaded valve.

Another absurdity is the present practice of license examiners asking a candidate questions dealing only with the fundamental and theoretical side of engineering and granting him a license, when he may not know much about the general repairs and upkeep of the plant he is to be in charge of.

Of course, an operating engineer is not expected to alter the construction of the boilers under his charge, but it is up to him to keep them in running order as well as the engines he will have charge of. What have other engineers to say on this subject?

Rochester, N. Y. R. G. SUMMERS.

Comments from Readers

Type of Stoker for Lignite Coal

In answer to the inquiry of G. B. Thomas on page 852 of the Nov. 25 issue, I would recommend the installation of chain-grate stokers of the forced-draft type, one having the air passages divided into sections. In this way the air supply could be regulated as wanted in any section of the grate.

I can assure him that no mistake would be made in installing a stoker of this type, but I would not recommend an underfeed stoker. Owing to the high forced draft necessary with an underfeed stoker, great difficulty is experienced in maintaining a uniform fuel bed when burning lignite coal. L. B. SHIELDS.

Chicago, Ill.

Analyses of Boiler Compounds

Our attention has been called to an abstracted article, appearing on page 859 of the Nov. 25 issue on the analyses of boiler compounds.

Being more or less of an authority on the subject, we glanced through the analysis and subject matter with interest, but were disappointed to note that the compilers of this material have assumed that all waters should be treated with soda ash, and arguments as to relative cost are based entirely on the soda-ash content in a compound.

This is not true, as there are many waters to which it would be almost criminal to add treatment containing soda ash, and there have been so many discoveries in recent years which have given the chemists treating feed waters so many new and more effective materials for use that soda ash has become really the lazy man's remedy for all things.

D. K. FRENCH, Directing Chemist,
Chicago, Ill. Dearborn Chemical Company.

Boilers for Heating Purposes

I have read with interest the article by Egbert Douglas in the Nov. 18 issue, referring to boilers for heating purposes. I agree with a great deal of this comment, but I think that a wrong impression might be obtained from it. Might it not be possible for one to get the impression that all firebox boilers for heating purposes were condemned by this article? I am sure that there are many instances where the use of any other than the firebox type of boiler would be unwise.

Today there is on the market a firebox type of boiler which by reason of its design is very efficient and can be built for safe working pressures from 125 to 150 lb. The design embodies a double pass of gas through the tubes, giving exceptionally long travel and combined with a down-draft furnace will give an over-all efficiency as high as 76 per cent. Tests by the Bureau of Mines on this type of boiler have proved this figure and at 150 per cent of rating.

In many cases the total installation cost of boilers of this type would be less than that of horizontal return tubular boilers which would need stokers or an elaborate brick setting to get the same efficiency. To make a fair comparison, cost of boiler, rigging and setting must be included.

I believe that in many cases the type and size of the boiler is determined after the building is completed, by the limited space that has been set aside by the designer as a boiler room. I have worked on many such jobs and I believe that the consulting engineers can be justly criticised for this as well as the architects. They too often accept the work of laying out the mechanical equipment, and do not insist on sufficient room to permit the use of equipment best suited for the conditions. Anything that will go in the space will have to do whether it is good engineering or not. If the space for this equipment were made to fit the mechanical requirements, I am sure there would be fewer installations similar to those cited.

Cincinnati, Ohio. S. R. IRISH.

Chimney Linings and Air Infiltration

The article by N. T. Bourke in the Nov. 25 issue on "Chimney Linings and Air Infiltration," and an editorial in the same issue entitled "Will Higher Linings Increase Stack Draft?" are of general interest, and let us hope this is the beginning of the end of guesswork in chimney design. We have theories galore but very few facts.

Mr. Bourke presents four curves representing flue-gas temperature at various parts of the stack, and of particular interest in these curves are temperatures at and directly above the stack lining. The writer of the editorial apparently agrees with Mr. Bourke that the rapid drop of the flue-gas temperature, at the top of the stack lining and in the ten feet directly above it, is due to air infiltration from the air space between the lining and the stack, as well as to a greater conductivity of the unlined section of the stack. No other factor is mentioned.

However, the temperature curves seem to lend themselves to an interpretation different from this one. The curves indicate that the temperature of the flue gases begins dropping rapidly at the point where the gases leave the lined portion of the stack, that in passing the first ten feet above the lining the temperature drops 20 deg., that in passing the second ten feet it drops another 10 deg., and then the reduction of temperature becomes more uniform and gradual.

Now without minimizing the importance of air infiltration and the insulating effect of the lining and air space between the lining and the stack, let us ask the question, "Could these two factors come into play and cause such a rapid drop of gas temperature beginning at the top of the lining and in the first ten feet above it?" Before answering the question, let us clearly visualize the prevailing conditions: First, the iron part of the chimney on the outside in contact with the outside air; second, the air space between the metal

and the lining; finally, the lining at least four or four and a half inches thick at the top.

Between the gases, as they leave the lined portion of the stack, and the stack itself is a space now unoccupied by the lining, and a stream of air coming from the air space. There is no provision to obtain a mixture of gas and air other than by diffusion. Air from this space is moving in the same direction as the gases and requires more time than one-half second before its effect can be expected to show up. The time required to pass the first ten feet above the lining is less than one-half second. For the reasons just stated, the gases leaving the lined portion cannot come into contact immediately with the unlined stack. Therefore the effect of air infiltration and the greater conductivity of the unlined portion of the stack could not cause the drop shown by the curves directly above the passage of the first ten feet above the lining.

The chances are that neither of the factors mentioned do come into play as a major cause for temperature reduction of the flue gases until the second ten feet have been passed, or twenty feet above the lining. The drop indicated at or near the top of the lining is, in my opinion, due to the work of expansion. The flue gases, on leaving the smaller area of the lining and passing into the greater area of the unlined portion of the stack, expand and the work is indicated by the temperature drop. The gases, on leaving the lined portion, expand at first very rapidly, and as the expansion progresses the pressure difference gradually is reduced and the mentioned factors become active.

The curves are of considerable interest as indicating the similarity between temperature drop and gas expansion, aside from being a study of stack losses. If this point is sustained by facts in further investigation, as I have no doubt it will be if the investigation is carried out with proper precision, it will establish facts having a great bearing on breeching design. At present, gas passages are generally designed with a larger area than the last passages in the boiler, presumably to save friction loss. If data are procured showing loss by expansion, then it will be up to the designer to decide which of the evils he prefers, the imaginary loss due to friction or the actual loss due to expansion, in both cases considering only preventable loss.

H. MISOSTOW.

Chicago, Ill.

Why Are Ammonia Fittings Not Standardized?

In the Nov. 18 issue, R. G. Summers asks why ammonia fittings are not standardized. It certainly would be convenient if these fittings were interchangeable, but as the manufacturers do not make it convenient for the operator in this way, why should the operator bother with fittings?

At the present time developments of welding operations have reached the point where a torch skilfully used will make a quicker and less expensive job than that resulting from the use of fittings. This is particularly true on small pipe work, where pipe may be bent or otherwise adapted to meet conditions of the job.

Of course the hazard is that, having acquired some skill with the torch, a mechanic will attempt to weld up a vessel, which is distinctly a shop job, demanding careful testing. However, with proper limitations the welding torch has become a most useful item in the outfit of a refrigerating plant of considerable size. The advantages of welding over the use of fittings have been demonstrated by our experience in the past several years, during which time we have introduced its use in a number of our plants and are each year more pleased with the results and economies produced.

H. L. LINCOLN, Supt. of Factories,

San Francisco, Calif. The Union Ice Co.

Pulverized Coal vs. Stoker at Brunot Island Power Station

I read the article of L. W. Heller in the Oct. 14 issue entitled "Pulverized-Coal Boiler Performance, Brunot Island Power Station." Conditions of heating surfaces not being the same for the stoker and the pulverized-coal installation, it seems rather difficult to conclude that the net efficiency, six points higher for the pulverized-fuel-fired unit than for the stoker-fired unit, is due to the use of pulverized fuel.

If comparative tests were made between two boilers Nos. 1 and 2 of the same type and size and equipped with the same stokers, but boiler No. 2 being supplied with an economizer, it is evident that the combined efficiency for No. 2 would be much higher than for No. 1. Yet, the stokers being exactly the same, it is obvious that we could not conclude that stoker No. 2 is better than stoker No. 1. The same conditions exist at Brunot Island Power Station.

The water screen added in the pulverized-fuel system increases the direct heating surface of the boiler by 180 sq.ft. It is well known that the absorption of heat by radiation and consequently by the direct heating surface is much more important than the absorption by the indirect heating surface. Experiments have proved that about 70 per cent of the total evaporation of a boiler is produced by the direct heating surface. Consequently, the fact of increasing considerably this direct heating surface, as is the case at Brunot Island Station, automatically increases the amount of steam generated by this surface, which is a first reason for a higher efficiency.

Moreover, the heating surface of the superheater has also been considerably increased, almost one-tenth of the heating surface of the boiler, exactly 776 sq.ft. This is another reason for an increase of efficiency. Consequently the increase in efficiency is, in my opinion, due to the improvements of the boiler itself rather than to the system of combustion.

If the stoker-fired unit had been improved in the same way, by installing water screens on the sides, front and bridge walls and also by the use of a superheater having 1,031 sq.ft., its efficiency would have been the same as that of the pulverized-coal unit. The experiences at Hell Gate Station have plainly proved the high efficiencies obtained with such devices applied to stoker-fired furnaces.

The increase of efficiency due to the water screen is shown in the results of the tests made at Oneida Street Power Station, published in Bulletin 223 of the Bureau of Mines, which gives a good idea of the increase of efficiency due to the water screen. Add to this the increase in efficiency due to the large increase of the superheater surface, and it seems to me rather difficult to conclude that the superiority is due to the system of combustion itself.

The curves of exit-gas temperatures, Fig. 4, are self-

explanatory, and the differences shown are due to the differences of heating surfaces of the units in both cases.

The accumulation of slag, ash and soot occurring with a stoker-fired furnace pointed out by Mr. Heller may be due to the fact that the stokers are equipped with steam jets above the fuel bed. The suggestions given in my article in the Aug. 26 issue will do much to obviate this fault.

Moreover, owing to the perfect porosity maintained in the entire fuel bed, a high percentage of CO_2, as high as 16 per cent and more, may be maintained without the formation of CO. Also, the stratified flow of gas pointed out by Mr. Ricketts in his article on "Boiler Furnace Design" in the May 13 issue, is practically eliminated.

Another advantage of the perfect porosity of the fuel bed and of the elimination of the big lumps of coke is that the excess of air necessary with a number of the existing underfeed stokers might be reduced to a minimum—another feature that will increase the stoker efficiency.

Consequently, the troubles of the stoker pointed out by Mr. Heller would not only be avoided, but the stoker efficiency would be considerably increased. Hence an efficiency at least equal to that of the pulverized coal would be obtained; a fact already corroborated by the tests made at Hell Gate Station with a standard stoker of relatively old design.

The curves in Fig. 4 relative to the auxiliary power needed by each system, as given by Mr. Heller, show that the auxiliary power for the stoker is about half the amount used with pulverized coal. If you add to this saving the amortization of the first cost for both systems and also the cost of maintenance, when all computations are taken into consideration, conditions of boilers being the same, my opinion is that the stoker is more economical.

MAURICE RATEL.

New York City.

Measurement of Air Removed from Surface Condenser

A full answer to the problem raised by A. R. Roberts in the Nov. 18 issue, would require a little more data and a great deal of space. The measurement of the flow of air can be made simple and accurate so long as the assumptions made are correct. Although many other methods of measurement are available, the orifice method is the most direct. An important point to remember when adopting data dealing with orifices is that it is essential to observe that the figures given in the various engineering society transactions and pocket books apply over the range of values and conditions for a particular case.

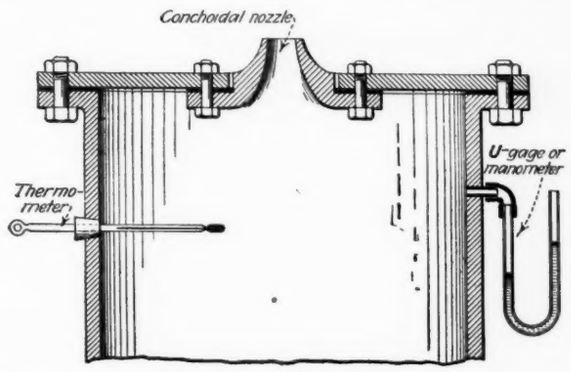
Since a centrifugal hydraulic vacuum pump does not give pulsating flow, no error should arise from this cause. A small back pressure must be used, so as not to interfere with the efficiency of the air pump; one or two inches of water pressure drop are quite enough to measure the flow.

The first thing to decide is the size and shape of the orifice. By consulting available data an assumption must be made as to the probable air leakage with the vacuum registered at the turbine; it may be around 200 lb. per hour. With this knowledge the size of the orifice, which may conveniently be made of an easy working dimension, may be determined from its discharge coefficient and the formula given herewith. For small pressure drops the hydraulic formula, which is accurate within 1 per cent up to 12 in. water gage, may be employed; it is

$$Q = AC\sqrt{\frac{2gP}{D}}.$$

where Q is the discharge in cubic feet per second, A the area of orifice in square feet, C the discharge coefficient, P the pressure drop in pounds per square foot, and D the density of fluid-pounds per cubic foot.

D, the density, can be calculated from the known temperature and pressure conditions just before the nozzle, using the equation $P.V. = R.T.$ This applies only to dry air, and allowance should be made for saturation. The air will probably be saturated, and the pounds of water per cubic foot of air at the given



Arrangement of nozzle and gages for measuring air flow

temperature may be found from tables. The error in assuming the air to be dry, however, is only about 1 per cent.

The form of nozzle must be decided by judgment and great care exercised in making it. If a plain orifice cut out of plate is used, the discharge coefficient will be in the region of 0.6; a suitable value may be found from the numerous published data. It should be noticed, however, that the coefficient is affected by size, temperature, pressure ratio, velocity of flow, thickness of plate and the condition of the edges. All the conditions of calibration should be noted. The conchoidal orifice, though more difficult to make, is more accurate over a wider range and has a discharge coefficient of very nearly unity.

The pressure drop may be measured by a manometer placed a short distance from the orifice with one leg of the gage open to the atmosphere. The nozzle may discharge straight to the atmosphere, and the downstream pressure is read on the manometer. The upstream pressure used to determine the density is the manometer pressure plus the drop. The usual correction for temperature and pressure, to reduce to terms of "free" air, may be introduced if desired.

The nozzle may be bolted to a flange at the end of the discharge pipe, as little error is likely to arise from shock and eddying with a pipe of this diameter. A conchoidal nozzle passing 200 lb. of air per hour, giving 2 in. of water pressure drop, would have a diameter of about 1.25 inches.

H. B. THOMPSON.

New York City.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Double Riveted Girth Seams

Why are not girth seams of horizontal return-boiler boilers made with double-riveted in place of single-riveted lap joints? *J. L. G.*

A double-riveted lap joint has considerably more metal in it and therefore is not so well adapted for girth seams of externally fired boilers as single-riveted lap joints. However, for locomotive or other internally fired boilers, where the shell is subjected to severe transverse stresses, double riveting is highly desirable for the girth joints.

Importance of Counterbore for Engine Cylinder

To make a good job of reboring the cylinder of one of our engines, the finishing cut would increase the main bore to the diameter of the present counterbore. Would it be necessary to rebore the counterbore? A. R.

A counterbore may not be necessary for temporary operation of the engine, but without a counterbore at each end of the cylinder for the piston packing to override, the wear of the piston soon leaves shoulders, which cause leakage by disturbing the adjustment of the piston packing, from which it is likely to become broken and cause serious scoring of the cylinder.

Equivalence of Gage Readings at Different Altitudes

At a place that is about 3,000 ft. above sea level, where the barometer is 26.33 in. and temperature 42 deg. F., what vacuum gage reading and boiler pressure would be the same as 26 in. vacuum and 200 lb. gage at sea level? *H. A. H.*

The mean atmospheric pressure at sea level is 14.7 lb. per sq.in., corresponding to the pressure of a mercury column 29.92 in. high at the temperature of 32 deg. F. In condenser practice it is customary to refer vacuum gage readings to 30 in. barometer, and for that height the standard atmospheric pressure of 14.7 lb. per sq.in. would be obtained when the temperature of the mercury is 58.4 deg. F., and for 26 in. vacuum and this standard temperature of mercury the absolute pressure would be 30 — 26 = 4 in. of mercury or $4 \times 0.49 = 1.96$ lb. per sq.in. absolute.

The coefficient of expansion or contraction of mercury is 0.000101 per deg. F., and for the temperature 42 deg. F. the height of mercury column to equal 4 in. at the temperature 58.4 deg. F. would be $4[1 - 0.000101(58.4 - 42)] = 3.99$ in. Hence where the height of the barometer is 26.33 in. with the temperature 42 deg. F., the height of mercury in the vacuum gage would be 26.33 — 3.99 = 22.34 in.

Since at sea level the standard atmospheric pressure is 14.7 lb. per sq.in., it follows that 200 lb. gage pressure would be equal to 200 + 14.7 = 214.7 lb. per sq.in. absolute. At a place where the barometer is 26.33 in. at the temperature 42 deg. F., the barometer height for the standard temperature of 58.4 deg. F. would be

$26.33[1 - 0.000101(58.4 - 42)]$

$= 26.28$ in., or $26.28 \times 0.491 = 12.87$ lb. per sq.in.

and for 214.7 lb. per sq.in. absolute, which would be the same as 200 lb. gage at sea level, the pressure would need to be 214.7 — 12.87 = 201.8 lb. gage.

Equivalent Evaporation

What quantity of water fed at the temperature of 200 deg. F. must be supplied to a boiler for generation into steam at 200 lb. gage, superheated 150 deg. F., for the output to be equivalent to evaporation of 1,000 lb. of water from and at 212 deg. F.? *H. S. G.*

Evaporation of one pound of water from and at 212 deg. F. requires the latent heat of evaporation at that temperature, namely, 970.4 B.t.u., and 1,000 lb. would require 970,400 B.t.u. According to tables of properties of superheated steam, one pound of steam at the pressure of 200 lb. gage, or 215 lb. per sq.in. absolute superheated 150 deg. F., contains 1,284.6 B.t.u. above 32 deg. and with evaporation from feed water at the temperature of 200 deg. F., each pound of the feed water would receive from the boiler 1,284.6 — (200 — 32) = 1,116.6 B.t.u.

Hence the weight of feed water required of steam generated under these conditions that would be equivalent to evaporation of 1,000 lb. of water evaporated from and at 212 deg. F. would be 970,400 ÷ 1,116.6 = 869 lb.

Overheating of Air Compressor

We have a 5½x5-in. stroke air compressor. The air cylinder becomes so hot as to cause paint or oil on the outside to smoke. What is the reason for such overheating? H. D.

Overheating of the air cylinder might result from burning of the cylinder lubricating oil, especially if the cylinder is not water cooled or if the cylinder lubricating oil has too low a flash point, or having insufficient circulation of cooling water of low temperature, or from a combination of these causes. Excessive heating also may result from leakage of the discharge valve. The air attains higher temperature from compression, and when the discharge valves leak, part of the heated compressed air, in place of being delivered to the receiver, finds its way back into the cylinder and is recompressed along with the free air taken in for compression with building up of a high temperature of the cylinder.

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Figuring Efficiencies of Oil and Gas Engines

AS COMMONLY defined, efficiency is the ratio of useful output to input. This definition may be applied to a group of machines (a generating unit, for example), a single machine or part of a machine.

One of the simplest examples is the over-all, or "thermal," efficiency of an oil or gas engine. Such an engine may be connected to a prony brake or other device for measuring the power output. By measuring the input of fuel, the efficiency may be readily computed if the amount of heat or energy in the fuel is known. Before starting readings on such a test, the engine should be run long enough at the given load for the conditions to become constant. Where a prony brake is used, the power delivered is figured by the formula, Brake horsepower = 0.0000159 × length of brake arm in inches × net load on the end of the arm in pounds × r.p.m.

Suppose that an oil engine during the course of such a brake test consumes 398 lb. of oil having a heating value of 18,900 B.t.u. per lb., that the power delivered is 204 b.hp. and the period of the test is five hours. Then the hourly fuel consumption is 398 ÷ 5 = 79.6 lb. The oil consumed per horsepower-hour is 79.6 ÷ 204 = 0.390 lb. This represents an hourly heat input of 0.390 × 18,900 = 7,370 B.t.u. The useful output of 204 hp. must be reduced to the same basis. One horsepower-hour is equivalent to 2,545 B.t.u. That amount of heat is produced in the brake by friction for each horsepower-hour delivered. The over-all, or "thermal," efficiency is then 2,545 ÷ 7,370 = 0.345, or 34.5 per cent.

As another example of efficiency computations take the case of a one-hundred horsepower natural-gas engine driving a generator. Operating conditions make it impracticable to run a brake test, but an indicator is available, as well as the manufacturer's curves showing the efficiency of the generator at all loads. It is desired to obtain the efficiency of the unit and its various parts for a generator load of approximately 110 kw. A test can be run by holding the load as closely as possible to this point for a reasonable period, noting the actual load at regular intervals and taking the necessary gas-meter readings. At the same time indicator diagrams may be taken for figuring the indicated horsepower. Suppose the data obtained from such a test are as follows:

Average electrical output, 107 kw.
Average indicated power, 181 i.hp.
Generator efficiency (from curves) at given load, ...92 per cent
Gas consumed per hour, 1,610 cu.ft.
Heat value of gas per cu.ft., 960 B.t.u.

From these data it is possible to figure several different efficiencies corresponding to the points at which input and output are measured. Taking everything on an hourly basis, the input of the engines is 1,610 × 960 = 1,545,000 B.t.u. The indicated horsepower is the *output* of the expanding gases and the *input* of the piston. This will be 181 × 2,545 = 460,600 B.t.u. Skipping, for the moment, the output of the engine at the shaft or the "brake" output, the output of the generator is 107 × 3,415 = 365,400 B.t.u., since one kilowatt-hour is equivalent to 3,415 B.t.u. The generator efficiency is 92 per cent, which means that the generator output is 92 per cent of its input. The input must therefore be 365,400 ÷ 0.92 = 397,200 B.t.u. This is likewise the equivalent of the "brake" horsepower.

We then have the following hourly quantities of energy handed on from one section of the unit to the next.

Item	Amount B.t.u.	Delivered By	Delivered To
Heat in gas...	1,545,000	Gas supply	Engine intake
Indicated horsepower	460,600	Heated gases	Piston
Brake horsepower	397,200	Engine shaft	Generator
Electrical output.....	365,400	Generator	Line

The over-all thermal efficiency of the unit as a whole will be its output divided by its input, or 365,400 ÷ 1,545,000 = 0.236, or 23.6 per cent. When considering the over-all thermal efficiency of the engine alone, the input is 1,545,000 B.t.u. as before, but the output is the 397,200 B.t.u. delivered to the generator. This efficiency then becomes 397,200 ÷ 1,545,000 = 0.257, and may be termed the brake thermal efficiency.

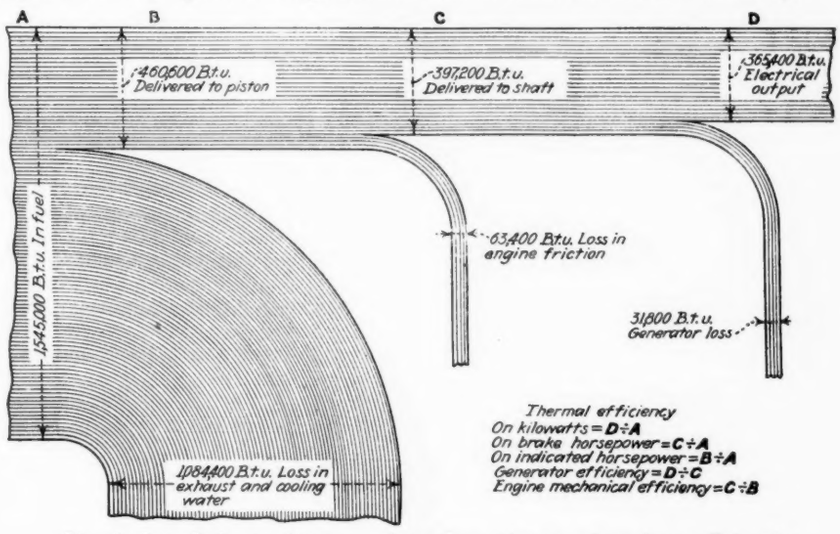
While the brake horsepower of an engine has more practical significance than its indicated horsepower, there are many cases where it is difficult, if not impossible, to make any direct measurement of brake horsepower. The ease with which electrical outputs can be measured, together with the possibility of obtaining (or preparing) curves giving the generator efficiency at all loads, makes it easy to estimate the actual brake horsepower of generating units and the corresponding economy and efficiency of the engine.

Where the engine drives non-electrical apparatus, such as a compressor, it is generally necessary to fall back on the indicated horsepower. In the example under consideration the indicated horsepower is not essential, but it does give valuable additional information.

For one thing, the mechanical efficiency of the engine may be figured. The mechanical efficiency is the output of the engine mechanism divided by its input, or 397,200 ÷ 460,600 = 0.861 or 86.1 per cent.

Another efficiency is the thermal efficiency based on indicated horsepower, or the efficiency from fuel to indicated horsepower. This is 460,600 ÷ 1,545,000 = 0.298, or 29.8 per cent.

From the point of view of the purchaser and user, the most important of all these efficiencies is the over-all thermal efficiency of the unit from fuel to electricity. What interests him is the fraction of the energy supplied in the fuel that reaches the switchboard. The locations and amounts of the various losses are of practical interest to the user only to the extent that they are capable of reduction. The designer and builder has more to gain from an analysis of the performance of the unit part by part. Such a study shows him where he can make improvements that will increase the over-all efficiency.


A
B
C
D
460,600 B.t.u. Delivered to piston
397,200 B.t.u. Delivered to shaft
365,400 B.t.u. Electrical output
1,545,000 B.t.u. In fuel
63,400 B.t.u. Loss in engine friction
31,800 B.t.u. Generator loss
1,084,400 B.t.u. Loss in exhaust and cooling water
Thermal efficiency
On kilowatts = D ÷ A
On brake horsepower = C ÷ A
On indicated horsepower = B ÷ A
Generator efficiency = D ÷ C
Engine mechanical efficiency = C ÷ B

Simple heat-balance diagram gives clear picture of various efficiencies

Carnot's Principle Explained

By M. I. PUPIN

Professor of Electrodynamics at Columbia University

ONE hundred years ago a principle was discovered which marked the beginning of a new era not only in the history of science, but also in the history of all human thought. Its great discoverer was Nicholas Leonard Sadi Carnot, and hence the name Carnot's Principle. The fame of the discoverer has never passed beyond the boundaries of a comparatively small circle of scientists and engineers. This may seem strange, but it is not as strange as the historical fact that it took fully twenty-six years before that discovery could find its way even into the tiny circle of the foremost scientists of Europe. The reasons for this delay of recognition are not far to seek.

Carnot's Principle, as originally formulated by the discoverer, is the only trusty guide in our studies of the operations by which heat is harnessed to do mechanical work and render service during its passage from a higher to a lower temperature level, an operation so well illustrated by the performance of the steam engine. But in order that heat may perform that service, it is necessary to guide it in its passage from higher to lower temperature levels by a suitable mechanism, and Carnot described an ideal mechanism by means of which the maximum service is obtainable.

Carnot Only Twenty-Eight

Carnot was only a youngster of barely twenty-eight, and perfectly unknown to the academicians of France, when in 1824 he published his epoch making essay "On the moving power of fire." The concepts of "work and energy," so clearly defined in Carnot's mind, had only just begun to find their way into scientific thought, so that as we look back today we cannot help thinking that Carnot was far ahead of his time; he was a prophet, and a prophet is always hard to understand. Hence the long delay of recognition; it came nearly twenty years after Carnot's death in 1832, when he was only thirty-six years of age.

The prophet differs from the ordinary man by the intensity of the impressions which the environment makes upon his mind. He is a man of inspiration. What inspiration guided Carnot in his prophetic thoughts? Was it the operation of the steam engine, and nothing else? I do not think so, but even if it had been so, then another question would arise, the question, What inspiration guided the inventor of the steam engine? I shall now touch upon a subject so well discussed last Tuesday by Doctor Low, the retiring president of the American Society of Mechanical Engineers.

We recognize today that there is, as Mr. Low said, a cosmic stream of solar energy from which everything that lives and breathes on this terrestrial globe derives its driving force, just as the mill on the mountain side derives its driving power from the mountain stream. This cosmic stream of energy is the mighty flow of solar radiation. The oceans catch it and derive from it the lifting power of their vaporous water masses, which, driven by atmospheric currents, distribute their precious loads over the thirsty continents. Countless billions of drops of water are thus carried by solar radiation to the highest continental elevations, and before they return to the oceans again each one of them has performed a definite mission.

No relief expedition has ever performed a more precious service to terrestrial life than these tiny messengers of our terrestrial oceans. If science could find a Homer who would describe in suitable language the adventures of some of these drops of water on their cyclic journeys from the oceans to the continents and back again, the world would read an epic alongside of which Homer's Odyssey would sound like a commonplace and vulgar tale. This Homer of science has not yet been found, although five thousand years ago the poets of Rig-Veda and of Mahabarata told us that in those days man's mind saw in this solar energy stream and in the service which it rendered to terrestrial life a new divinity and founded a religion of solar worship. This was the result of the ancient inspiration.

MANY years ago an immigrant boy, Michael I. Pupin, set foot on American soil and gazed in amazement at the network of overhead wires in downtown New York. Today, thanks to his inventions, these wires are underground and telephone conversations from coast to coast are an everyday occurrence. All this is recounted in Professor Pupin's recent book, "From Immigrant to Inventor." Few men have delved deeper into nature's secrets and none has a happier gift for revealing their significance to others. This illuminating address on Carnot's Principle was delivered by Professor Pupin at the celebration of Carnot's centenary on December 4 at the annual meeting of the A.S.M.E.

Sun Worshippers and Engineers

Contrast now with this ancient mind the modern mind of the inventor of the steam engine. Where one saw the resplendent sun god, the other saw a celestial fire and imitated it by a terrestrial fire under a boiler. Where one saw the blessings of the sun god manifesting themselves in the healthy growth of terrestrial life, the other saw evaporation of the oceans and the gigantic mechanism which lifts the enormous water masses destined to irrigate the continents; he imitated it by providing the boiler of the steam engine which by the pressure of its steam drives the piston of the steam engine and does work which relieves man of his heaviest burdens.

The cosmic operation, as well as its tiny terrestrial imitation, the steam engine, employ the same cyclic process of harnessing heat in its passage from higher to lower temperature levels for the purpose of making it serve man, just as the mountain stream in its downward course serves the happy miller on the peaceful mountain side. But neither the ancient sun worshiper nor the modern inventor of the steam engine knew anything about the fundamental law in accordance with which heat performs this precious service to man. The revelation of this simple truth was reserved for a prophet who had the vision to see a new truth in physical phenomena that have become commonplace, because from time immemorial they surrounded us on every side and all the time.

A Fundamental Idea

Now what is the fundamental truth that Carnot extracted from the familiar phenomena which accompany solar radiation and the operations of a steam engine?

The first part of this truth was an axiom, that is, a self-evident truth, and it is this: "Heat cannot perform mechanical work except when it passes from a higher to a lower temperature level." Carnot illustrates this axiom by pointing out that, similarly, water stored in a reservoir cannot do external work except when it passes from its own to a lower level.

Wherever, therefore, there is a difference of temperature levels there is a possibility of harnessing heat for useful service during its passage from the higher to the lower level. The blessings conferred upon our terrestrial globe by solar radiation have undoubtedly helped to suggest to Carnot this self-evident truth.

It is a matter of universal experience that direct conduction of heat from a hot body to a cold body in contact with it will produce no other effect than to raise the temperature of one and lower that of the other. No mechanical work is done under these conditions and, therefore, no service is rendered which forms the subject of Carnot's philosophy. That kind of heat transformation is a waste of opportunity according to Carnot; modern science calls it dissipation. When, however, we interpose a suitable instrumentality in the path of heat that is being transferred, then service may be rendered. This is what we call harnessing of heat.

The piston in the cylinder of the steam engine is such an instrumentality; it is a part of the harness. The steam in the cylinder expands and drives the piston against external pressure and thus performs work at the expense of a part of the heat of the steam, the other part passing on to the condenser. The steam engine with its well-known cyclic operations is a crude illustration, only, of what Carnot meant by an instrumentality that enables

heat to render service during its passage from a higher to a lower temperature level. Carnot himself described a much more perfect instrumentality for these cyclic operations; it is a steam engine idealized in its construction as well as in its mode of operation by expansion and compression.

It is not necessary to go into any detailed description of Carnot's poetic conception shown in his ideal engine and its ideal cyclic operations except to say that they are reversible. The scientific meaning of this term, first employed by Carnot, is best described by the statement that whatever changes occur during the cycle when it is performed in one direction will be reversed when the cycle is performed in the opposite direction. This is to say, if the heat is passed from a higher to a lower temperature level and a certain amount of work is delivered by Carnot's engine, then when the cycle is reversed the same amount of work delivered to the engine will transfer to the higher temperature level the same amount of heat, otherwise a *perpetum mobile* would be possible, and that, following the Newtonian dynamics, Carnot rejects as impossible.

The Principle Stated

Carnot shows then by the simplest kind of logic ever employed by a scientific mind that under these ideal conditions the maximum amount of mechanical work is obtained by the passage of a given quantity of heat from a given higher to a given lower temperature level, and that this maximum depends upon the initial and the final temperature and upon nothing else. This is Carnot's Principle. It can, therefore, be summed up briefly as follows:

Heat can do mechanical work by passing from a higher to a lower temperature level if suitably harnessed. When that passage is effected by means of a reversible cycle, the maximum amount of work will be obtained, and this amount will be independent of everything except the initial and the final temperature.

Twenty-six years elapsed before the full importance of this principle was clearly understood. Young William Thomson, who later became Lord Kelvin, but who at that time was only twenty-six years of age, was the first to decipher Carnot's message, and this enabled him to construct a new and absolute scale of temperature. It was then an easy matter to express Carnot's Principle in the various mathematical forms known today as the Second Law of Thermodynamics.

The first advance upon Carnot's work was the result of many efforts, notably those of great Maxwell, to explain dynamically the efficiency of the transformation of heat into mechanical work as demanded by the second law of thermodynamics. The first result of these efforts was the confirmation of an old belief that heat is a non-coördinated mode of molecular motion. This was vaguely suggested by many scientists of the Eighteenth Century.

The molecular motion in a hot gas offers the simplest illustration. We call that motion non-coördinated, because each molecule being practically an independent unit performs its motion according to its own sweet will, colliding incessantly with its neighbors. It is a chaotic state of motion, and we can say that among the enormous number of molecules contained in a cubic foot of a hot gas there is a chaotic distribution of kinetic energy. The function, then, of Carnot's piston is to receive the impulses due to this chaotic mode of motion and to transform them into a co-ordinated form of motion of the machinery connected to the piston. This is indeed a transformation of a chaos into a cosmos, and the highest efficiency obtainable by man is that given by Carnot's Principle.

The co-ordinating action of the Voltaic cell has been in the mind of many an investigator when he made the efforts to guide the chemical reaction between oxygen and carbon by the co-ordinating action of voltaic forces.

Permit me to refer again, briefly, to Mr. Low's inspired remarks on Tuesday last. I refer now to his sketch of the process of storing solar energy by the biological activity of the plant cell. This energy is radiated by myriads and myriads of solar atoms and molecules, which are practically independent of one another. Their activity is, therefore, chaotic, and the energy units which they contribute to the mighty stream of solar radiation form a non-coördinated system of energy distribution. The action of this chaotic system upon the plant cell is similar to the action of steam molecules upon the piston. The result of this chaotic action is a perfectly co-ordinated separation of oxygen from carbon; it is a co-ordinated form of work as the growth of the plant testifies. It is a beautiful transformation of a chaos into a cosmos, a beauty of order.

Each plant is a cosmos, a part of which is derived from the chaos of solar radiation. This action of the plant cell is, as Mr. Low says, still a secret. We can describe it briefly by saying that the plant cell has a co-ordinator which, like the Voltaic cell and Carnot's engine, guides chaotic activity into a co-ordinated form of rendering service. This description may perhaps do no other good than hitch the unknown unto something which is known and in this manner help to decipher the secret.

All Nature Granular

The more one studies nature the more clearly does he see that everything has a granular structure. There are the granules of matter, the atoms and molecules. Then there are the granules of electricity, the positive and the negative electrons. Then, again, there are the granules of life, the cells and the millions and millions of their constituent parts. Finally there are the nations with their millions of human granules. Each granule has an individual and more or less autonomous existence. A chaotic, a non-coördinated, activity results unless co-ordinators are introduced which transform the chaos into a cosmos.

I do not think that I am too optimistic when I say that some day Carnot's Principle will help us to understand these complex activities of life in the same way as it has helped us to understand the phenomena of heat, radiation and chemical action. At any rate I do not see any other scientific principle which unites the activities of the inorganic and organic world under one general and all-embracing concept.

Large Turbines Give Improved Service

DURING the year 1923 the history of eighty-seven large turbine units indicated that a greater demand was met with better response than in the previous years, as described in the recent report of the Prime Movers Committee, of the N.E.L.A., publication No. 24-57. It is gratifying to see that while the 1923 demand for operation was 5 per cent larger than that of the year before, this was met 1.5 per cent better than in 1922. The outage in units supplied from 1917 to 1920 is still traceable to raising the standard of construction, which characterized those of the war period.

While it has been difficult to obtain complete reports in all details of turbine operation, maintenance, etc., a satisfactory and complete report has been compiled of 87 units which generated about 20 per cent of the total kilowatt-hours estimated as being produced by all central stations during the year 1923. The total capacity represented is 2,506,000 kw.

Operation was demanded 78.4 per cent of the total hours during the year. On account of repairs, maintenance, adjustment, etc., however, these prime movers were able to operate about three-quarters of the total time during the year, or 72.4 per cent. The ratio of the time actually operated to that which was demanded, therefore, is 72.4 ÷ 78.4, or 92.3 per cent. In other words, repairs, adjustments, etc., prevented 7.7 per cent of the demanded operation.

The total kilowatt-hours generated during the period 1923 divided by the total unit kilowatt rating was 51.6 per cent. The unit rating here, refers to the total kilowatt rating multiplied by the entire number of hours in a year.

The ratio of the total kilowatt-hours generated during the period to the actual kilowatt-hour rating times the actual service hours, was 71.3 per cent, and the ratio of the actual service hours to the total hours during the year is 72.4 per cent. The maximum possible unit operation factor, which is the ratio of service hours plus the reserve hours to the total time during the year, is 87.1 per cent.

The total idle hours as charged against the different parts of the average unit installation are: Steam turbine, 7.33 per cent; generator, 1.74 per cent; condenser, 3.18 per cent; other causes, 0.66 per cent. The total time in the reserve period when the units were ready for immediate starting, although not called upon, was 14.69 per cent. These percentages refer to the actual hours for all units in an entire year, which is 8,760 hr. times the number of units.

It must be remembered that the period required for maintenance or re-

pairs on different parts of the unit does not represent the total hours actually given to each element. If the unit, for example, must be kept out of service on account of turbine work, this time is charged against the turbine, while other work, such as maintenance, may be done on the generator or condenser at the same time, although the generator or condenser would not be charged with the shutdown. Thus, idle time for maintenance or repairs which prevented the operation of the unit only is considered.

TABLE I—ANALYSIS OF STEAM TURBINE IDLE HOURS

	Percentage
Steam casing and joints	3.74
Governors	0.91
Control gear	1.58
Shaft packings	2.84
Nozzles and diaphragms	4.87
Shaft and coupling	0.07
Wheels or spindle	14.64
Buckets or blades	14.69
Vibration	1.08
Bearings	2.73
Lubrication system	2.26
Cleaning oil system	4.92
General inspection and overhaul	43.75
Miscellaneous	1.93
Total for repair and maintenance	100.00

Table I shows the percentage of the actual shutdown time as charged against different parts of the turbine, and the remaining tables analyze delays due to generators, condensers and other causes. The reserve time when ready for immediate starting totals 109,826 hours.

TABLE II—ANALYSIS OF GENERATOR IDLE HOURS

	Percentage
Vibration	16.80
Oil leakage	0.76
Armature core	4.08
Armature windings	14.54
Field windings	27.88
Exciter	12.09
Inspection and cleaning	20.7
Miscellaneous	3.16
Total for repair and maintenance	100.00

The report brought out that in one instance the productive hours were increased about 8 per cent in installations where prime movers were practically duplicates of one another, so that a complete set of repair parts could easily be maintained, in comparison with those where prime movers were of radically different types so that each required, to a large extent, its own special repair parts. One member company is pursuing the policy of standardizing very thoroughly on account of the advantages of interchangeability of parts.

TABLE III—ANALYSIS OF CONDENSER IDLE HOURS

Leakage	7.53
Cleaning	66.8
Tubes	14.52
Shell	0.76
Circulating pumps	6.32
Condensate pumps	1.09
Air pumps	1.39
Miscellaneous	1.59
Total for repair and maintenance	100.00

As the operating hours increase, there is less and less spare time for maintenance of the condenser. The latter is required now more by 3 per cent than in the previous year. Sixty-seven per cent of the time on the condenser is necessary for keeping the tubes clean. Divided water-box condensers with twin circulation as well as twin condensers, and single- or two-pass condensers with arrangements to reverse the water flow are recent measures adopted to allow partial cleaning without stopping operation. Condensers must give better performance in the future than in the past if higher steam pressures are to attain desired results.

TABLE III—ANALYSIS OF OTHER CAUSES

General piping	26.15
Boiler room	2.23
Plant (electrical)	45.71
Outside (electrical)	0.59
Miscellaneous	25.3
Total for repair and maintenance	100.00

Transmission by Belting and Shafting*

By G. A. Ungar, M.E.

THE power transmission by belt, in spite of the development of the electric motor drive, is still very extensively used. Because of this fact the basic principles of the mechanical drives are worth repeating. Modern belt practice, by providing greater safety to operators, correct methods of applying belt tension, and care of belts by proper dressings, has greatly extended the limits formerly imposed to belt drives.

The distance of two shafts connected by belt drive is relatively limited by considerations of belt contact with the pulleys for short center distances and belt sag. For longer distances space requirement is a deciding factor. It is highly desirable that belt speeds should be high, the limitations being chiefly due to centrifugal force acting on the belt. Leather, canvas and rubber belts are used within wide ranges of transmitted power, and the employment of steel bands or belts has lately extended the field of belt applications.

Of chains as power transmitters only the so-called silent chains will be touched upon. They are used extensively in place of belt drives for short shaft centers at heavy loads. Their principal advantages over belt drive consist of: short shaft centers; lesser width; elimination of slip; elimination of bearing overload due to excessive belt tension; longer life due to lubrication.

Alignment couplings are employed to compensate for misalignment of two shafts due to inaccuracy of mounting machine work or shaft deflection. To function satisfactorily under angular and eccentric shaft displacement, they should practically embody two close-coupled universal joints. These couplings follow a number of different designs, namely, the Oldham-type, the pin-type, external- and internal-gear type, etc. Flexible couplings are also available in many types employing steel springs, rubber, rubber fabric, leather bushings or belts as flexible members.

In the existing types of couplings as well as universal joints, speed limitation is caused by vibration due to lack of proper balance of the revolving parts and at the same time due to the fact that the revolving parts are restrained from assuming their free axis of rotation, in the event of unbalance, excepting within very narrow limits. The development of universal joints and couplings properly balanced and with a free axis of rotation will greatly increase the present operating limits.

Couplings Requirements

Metallic alignment couplings, in order to operate satisfactorily, must be lubricated and the design should be such as to retain an ample supply of lubricant and to permit its access to the moving surfaces. These requirements are difficult to meet and not many of the available types of universal joints can be considered as satisfactory from the view point of lubrication.

The length of a lineshaft is limited by considerations of the types of machines which it serves, power losses due to friction and also the effects of a breakdown of such a lineshaft upon the operation of the plant that it serves.

Considerations of the types of machines to be served, the extent of their simultaneous operation, the power loss due to idling lineshaft, have greatly contributed to the elimination of long lineshafts in modern pracice, substituting for it group drive for machines of similar characteristics by relatively short lineshafts.

While in many cases the speed of the lineshaft is determined by the type of machine drives, in the majority of cases it is limited by the type of bearings employed, as well as excessive frictional loads due to misalignment of the bearings or possible shaft deflection due to improperly spaced pulleys of gears or shafts of insufficient diameter. Static or dynamic unbalance or pulleys or gears, couplings and clutches also is a limiting factor.

Line Shaft Design

Operation of shafts at higher speed will not only permit the use of smaller lineshaft diameters, but also smaller pulleys, gears, etc., because of the reduced torque to be transmitted. Greater care, however, must be given to the type of bearings employed, to their lubrication, to elimination of misalignment and deflection, as well as to properly balanced rotary drive elements. Failures of lineshaft bearings or excessive frictional losses are frequently due only to excessive bearing loads caused by improper alignment or excessive shaft deflection. With these improper conditions remedied, not only bearing difficulties are remedied but in many cases an increase in lineshaft speed would be possible. To be satisfactory for higher speeds, however, plain bearings should be of correct mechanical design with ample lubricant chambers and with means to prevent intrusion of dirt and grit, as well as to prevent lubricant leakage.

Ball or roller bearings, which are now used extensively, can be readily operated at higher speeds and provide certain economies due to reduced bearing friction. The majority of these anti-friction bearings are furnished with housings designed to retain lubricant and keep out dirt.

*Extract of paper read at the Power Show, New York City, Dec. 1.

Recent Publications

Charles Proteus Steinmetz. By John Winthrop Hammond. Published by the Century Co., New York and London. Cloth; 5½x8 in.; 489 pages; 18 illustrations; indexed. Price, $4.

Dr. Charles P. Steinmetz during his life became such a heroic figure in engineering and scientific achievements as to require no introduction after passing down the long trail. This book is the authorized biography of a master mind who thirty-five years ago fled from the persecution of his native land to seek his fortune in America, which was a strange country to him. Fortunately, his biographer began writing the story during the Doctor's lifetime, as this made possible a first-hand narrative of his early life, which could not have been obtained otherwise. A number of the chapters were read and approved by Dr. Steinmetz before his death.

Beginning with a brief résumé on his ancestors, of whom little is known, we see him born a solitary child in Poland, cared for by an indulgent grossmutter until ready to start for school. His first half-day in school was so distasteful to him, that he is allowed to remain home for another year. During his early years at school he is only an average student, and has a particularly hard time to master the multiplication tables. However, by the time he enters Breslau University he has developed an unusual thirst for knowledge, so much so that the student body nicknamed him Proteus, a name which he afterward adopted in his Americanization process out of love for his college associates. How far he had advanced in mathematics during his years in college is best shown by his graduation thesis, the title of which, translated, reads, "On Involuntary Self-Reciprocal Correspondence in Spaces Which are Defined by a Three-Dimensional Linear System on Surfaces of the nth Order." Although completing his university work with high honors, he never obtained his degree, since he had to leave Germany at about this time on account of his Socialistic ideas. Going to Zurich, he remained about one year when a friend of his offered to pay his way to America on an immigrant ship, an offer which he accepts. After his arrival in this country his progress as an engineer and scientist was rapid, although handicapped by physical deformity that would have defeated and imbittered most men, and in a strange land the language of which he had to master.

His biographer pictures him, not as an executive or doer, but as a great thinker whose wisdom marches on ahead of the world's civilization like a great torch into realms unexplored. The human side of the man has not been neglected in the story, and Steinmetz was truly human. As his biographer has expressed it, "He was one of those wholly delightful people who somehow contrived to stay wholly human notwithstanding the brilliance of their renown." The author has told an intimate and interesting story which will be of interest not only to electrical engineers, but to everyone who enjoys the story of a man who won his way without the aid of influence, patronage or artificial boosting.

New Power Test Code for Stationary Steam Boilers Including Stokers, Superheaters, Economizers, and Air Preheaters. Published by the American Society of Mechanical Engineers at 29 West 39th St., New York City. Paper, 7¾ x 10½ in. Price, 60 cents to non-members and 55 cents to members.

In 1886 a committee appointed by the American Society of Mechanical Engineers formulated a Code for the testing of steam boilers, which soon became the standard practice of the profession and the basis upon which performance guarantees were drawn and settled.

At that time there were no other recognized rules for practice extant in this country. The Institution of Civil Engineers of Great Britain appointed a Committee on Tabulating the results of Steam Engine and Boiler Trials in 1897 and their report, made in 1902, is now under revision by a Joint Committee of the Institutions of Civil and Mechanical Engineers.

In the thirty-eight years that have elapsed since the adoption of the original A.S.M.E. Code, it has undergone several revisions made necessary by the progress of the art. Such a revision has just been completed and the Code is now available in the thoroughly up-to-date form in which it has been adopted by the Council of the A.S.M.E. as the approved standard practice of the profession.

The committee in charge of this 1923 revision is: Edwards R. Fish, vice-president Heine Boiler Co., chairman; Arthur D. Pratt, Babcock & Wilcox Co., secretary; Alex D. Bailey, superintendent of generating stations, Commonwealth Edison Co., Chicago; Albert A. Cary, consulting engineer, New York; Edwin B. Ricketts, assistant to chief operating engineer, New York Edison Co.

The earlier 1915 draft of the Code for Stationary Steam Boilers related primarily to tests made with coal, while the latest (1923) revision covers in a complete way tests with (a) solid fuels, (b) liquid fuels and (c) gaseous fuels. The use of each of these types is treated when stokers, superheaters, economizers and air preheaters are attached to the boiler.

The text of the Code has been completely rewritten and the "Data and Results" section has been developed in an entirely new form. It now contains separate tables for each combination of apparatus, each item of which is covered by an item in a corresponding section devoted to computations. As a result of this arrangement considerable time will be saved in computing tests made according to this standard code. To further facilitate the computations and record of stationary steam boiler tests, the A.S.M.E. is planning to issue in separate pad form the various data, heat balance and computation sections.

Magnets. By Charles R. Underhill. Published by McGraw-Hill Book Co., 370 Seventh Avenue, New York City, 1924. Cloth; 6x9 in.; 468 pages; 467 illustrations; 25 tables. Price $4.

This book is a practical treatise on electromagnetic devices, their circuits and the specific forms and characteristics of electromagnets and permanent magnets employed. The subject has been treated from the broad viewpoint that practically every electrical device employs electromagnets in some form or other, rather than from the more narrow scope of an electric coil arranged to move a plunger or armature. So it is, that the author's object in the book, as stated in his preface, "Is to treat broadly the general principles of apparatus electromagnetically operated and controlled, but particularly to treat electromagnets and permanent magnets in detail." Equations have been used sparingly and with the exception of one or two chapters the text has been presented in an easily readable form, and the mathematical deductions translated into the text.

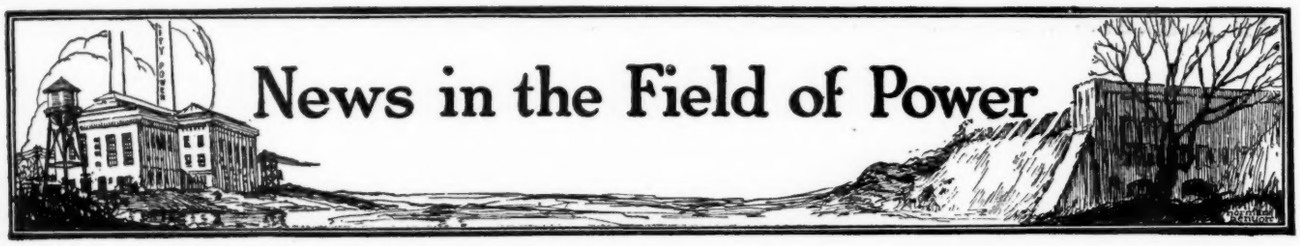
Among the more important chapters of the book are those that deal with: Forms of electromagnets; time and polarity characteristics; four chapters on solenoids; direct-current electromagnets (in this chapter are given the characteristics of a number of magnets for various classes of service); alternating-current solenoids; alternating-current electromagnets; electromagnets in general; and permanent magnets. One of the most interesting chapters is that on "Air Gaps and Magnetic Leakage," where the directions of the magnetic-flux path through air gaps and surrounding magnets are shown by means of steel filings. These are shown for different arrangements of two or more magnets and give a clean conception of the action of two or more magnetic fields under various conditions.

Although the book is intended primarily for college students and engineers, it is so comprehensive in its scope as to contain something for most everyone interested in the subject of magnets.

Power Studies in Illinois Coal Mining. By Arthur J. Hoskin and Thomas Fraser. Bulletin No. 144, a report prepared by Engineering Experiment Station of the University of Illinois, Illinois State Geological Survey and United States Bureau of Mines. Published by the University of Illinois, Urbana.

Kent's Mechanical Handbook. 10th edition in one or two volumes. Published by John Wiley & Sons., Inc., 440 Fourth Ave., New York City. Size, 4½x7 in.; 2,247 pages. Price in one vol., leather, $7; "Atholeather," $6; 2 vol. leather, $8.

Thawing Frozen Water Pipes with Electric Current, by D. D. Ewing and C. F. Bowman. Bulletin No. 7 Engineering Extension Service, Purdue University, Lafayette Ind.



Power Machinery Exported to Argentina

Exports of power-generating machinery from the United States to Argentina during the first half of 1924 increased over the figure for 1923 for the same period, according to *Commerce Reports*. There was exported from the United States power-generating machinery exclusive of electric, during 1922 $679,633; in 1923, $883,929; Jan.-June, 1924, $507,389.

A. E. C. Will Consider Public Works Dept.

The annual meeting of the American Engineering Council will be held in Washington Jan. 16-17, 1925. The Administrative Board of the Council will convene in that city on the previous day.

Co-operation of the engineering societies of the United States with the federal government in carrying out the provision of the Clarke-McNary Act and the policy of the engineering profession on the question of consolidating the Public Works functions of the government will be among the principal topics considered.

Stokers Sold During October and November

The Department of Commerce announces that according to reports received from 13 establishments, there were sold during October 104 mechanical stokers serving boilers with 585,650 sq.ft. of heating surface, of which there were 7 fire-tube boilers of 17,020 sq.ft. of heating surface and 97 water-tube boilers with 568,630 sq.ft. of heating surface. In November 106 stokers were sold serving boilers having 371,670 sq.ft. of heating surface; 11 fire-tube boilers of 16,750 sq.ft. of heating surface and 95 water-tube boilers of 354,920 sq.ft. of heating surface.

Largest Motorship Goes Into Service January 2

The "Aorangi," the world's largest and fastest motor passenger liner of the Canadian-Australasian Royal Mail Line, is to sail on her maiden voyage from Southampton on Jan. 2, according to press reports.

The "Aorangi" was launched recently from the yard of the Fairfield Shipbuilding & Engineering Co. on the Clyde. The vessel is 600 ft. in length with a beam of 72 ft.; has a registered tonnage of 18,500 and a displacement of 23,000 tons. She has four sets of Diesel engines, each developing 3,250 hp. at 125 r.p.m., and is capable of attaining a speed of eighteen knots. The vessel has accommodations for 950 passengers.

Smoke Nuisance and Fuel Problems To Be Studied

A study of the "utilization of the products of low-temperature carbonization of coal with particular reference to the economic production of smokeless fuel," is to be undertaken by the Department of Metallurgical and Mining Engineering of Carnegie Institute of Technology, of Pittsburgh, Pa., and the United States Bureau of Mines. The purpose of the study, which will be made by J. D. Davis, acting supervising chemist at the United States Bureau of Mines, and L. C. Karrick, a Carnegie Tech Research Fellow, is to devise means economically feasible for abatement of the smoke nuisance in cities such as Pittsburgh, Salt Lake City and Ogden.

The growing urgent demand for some practical means of combating the smoke nuisance in such cities is given as the reason for the intended study by the Carnegie Tech authorities. Furthermore, according to an announcement, it has long been thought that a smokeless fuel might be prepared by low-temperature carbonization of coal which would solve the problem.

Combined Carbonization Has Commercial Possibilities

While there has been much talk of low-temperature carbonization as a commercially feasible means of conserving natural resources and reducing the smoke nuisance, and while experimentation in this direction is active, 90 per cent of the coal now carbonized in this country is handled by the high-temperature process. This condition exists, not on account of any insuperable technical obstacles, but rather because the products of a ton of coal treated by the low-temperature process have, at present, a smaller market value than the products of the same ton treated by the high-temperature process. Pending increased demand for low-temperature tars, oils, etc., the commercial opportunities for low-temperature carbonization seem to lie chiefly in handling low-grade coals of little use for other purposes. On paper, at least, a combination of high- and low-temperature carbonization seems to offer better commercial opportunities than either alone. These were the principal points brought out by H. C. Porter, consulting engineer, in an address before the Franklin Institute, Philadelphia, on Dec. 18. The following brief abstract covers other points of particular interest:

While low-temperature coke would make a wonderful domestic and small-plant fuel, practically eliminating the smoke nuisance, the present market for byproducts hardly supports developments along this line. From coal worth one-quarter cent per pound it is necessary to get products valued at one-half cent to make the process pay. The main product is coke, the price of which generally pulls the total below this figure. For commercial processes better markets for byproducts are necessary, as well as reduced losses, operating costs and overhead charges per unit of output.

The accompanying table gives comparative figures on the value of the products obtained by the two processes from a pound of coal costing 0.25c. The combination process listed in the last column is not yet on a commercial basis, the figures given being mere estimates.

COMPARATIVE VALUE OF PRODUCTS FROM ONE POUND OF COAL COSTING 0.25 CENT

Process	High Temp.	Low Temp.	Combination
Coke at $6 per ton...	0.168	0.204	0.180
Gas at 5c per 100,000 B.t.u.	0.165	0.090	0.155
Tar and oil at 5c to 6c per gallon	0.030	0.072	0.072
Motor fuel at 20c....	0.026	0.026	0.030
Ammonium sulphate at 3c per pound	0.038	0.012	0.027
Total receipts ...	0.427	0.404	0.464
Balance available to cover fixed charges, conversion costs and profit	0.177	0.154	0.214

This table shows why low-temperature commercial development is slow and indicates the importance of more work on combination processes in which part of the distillation is carried out at high temperatures and corresponding high speed, while the distilled oils and tars are protected from destructive temperatures.

The low-temperature process has one advantage not shown by the table; that is, its ability to handle low-grade coals, screenings, lignitic coals, etc., of low cost. The acceptance of the low-temperature tars for such uses as creosoting timber would help the low-temperature process. Low-temperature coke makes an excellent substitute for domestic anthracite. This market may open up.

Engineering and Industry Museum Designed

A suitable building to house the exhibits of the National Museum of Engineering and Industry has been designed by Frederick A. Waldron, of the American Society of Mechanical Engineers in co-operation with the Smithsonian Institute and the Fine Arts Commission which is charged by Congress with the beautification of the National Capitol. The building site is the Mall, near the present Smithsonian Institute and is to be 1,150 ft. long by 200 ft. wide with classic facades. There will also be branch museums.

Gold Medals of the American Society of Mechanical Engineers

A.S.M.E. Medal, Melville Medal and Holley Medal Available for Award

BESIDES many prizes of various kinds, the American Society of Mechanical Engineers, through bequests and gifts, has three gold medals which it awards. Two of these have just been designed. The medals are:

Melville Medal

The Melville Prize Medal for Original Work represents the interest on a bequest made by Rear-Admiral George W. Melville, president of the Society during 1899, and can be given annually to such competing members of the Society as shall present an original paper or thesis of exceptional merit on any mechanical subject presented to the society for discussion and publication. The fund was established in 1912 at the death of Admiral Melville, but on account of lack of funds the medal had not been made until this time and has not been awarded. This medal has been designed recently by James Earle Fraser and is shown in the accompanying illustration. The obverse shows a symbolic figure of "Power" holding the reins of industry in one hand and a torch in the other with a background depicting the industrial arts. The reverse side carries a delightful portrait of Admiral Melville.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ADMIRAL GEORGE WALLACE MELVILLE
ENGINEER IN CHIEF
UNITED STATES NAVY
GIVE ME WHERE TO STAND AND I WILL MOVE THE EARTH
HOLLEY MEDAL
SOCIETY OF MECHANICAL ENGINEERS AMERICAN

The obverse and reverse side of the Melville medal is shown at the top; the center is the A.S.M.E. medal; and the lower the Holley medal

A.S.M.E. Medal

The American Society of Mechanical Engineers medal, for some notable invention or striking improvement in connection with the industries was established in December, 1918, and is awarded to members or non-members alike. To obtain this medal, any member may present the name of an engineer, forwarding a full statement of the grounds upon which the award might be expected, such statement to be published in the *Mechanical Engineering*. The design of this medal is also by James Earle Fraser, and the obverse is like the Melville Medal while the reverse has an extremely interesting sculptural interpretation of the Archimedian motto of the society, "Give me where to stand and I will move the earth." This is the motto that is on the seal of the society and it is also around the circumference of the medal. The name of the recipient and other data are to be formed on the rim in raised letters by means of a special die. These medals are 2⅝ in. in diameter. This medal has been awarded to John R. Freeman and Frederick A. Halsey.

Holley Medal

The Holley medal was established in January, 1924, by George I. Rockwood, vice-president and a life member of the society, and is named in honor of Alexander Lyman Holley, a founder of the society and chairman of the organization committee. It is awarded for great achievement only and "in those rare cases where an individual has succeeded by the exercise of his genius and character in powerfully assisting the fortunes of our country or the general engineering progress of the world." The award was made for the first time to Hjalmar Gotfried Carlson "for his inventions and processes which made possible the timely production of drawn steel booster casings for artillery ammunition, thereby aiding victory in the World's War." This medal is awarded to both members and non-members. The design was made through the combined efforts of Desmond Fitzgerald, engineer and artist, of Boston, and John Wilson, of the Department of Sculpture of Harvard University.

Large Power Plant for Texas Started

The Electric Bond & Share Co. has announced plans for a large electric generating plant to be constructed by the Texas Public Utilities Co., a subsidiary of the Southwestern Power & Light Co., which is controlled by the American Power & Light Co. The new station will have an ultimate capacity of 150,000 kw. and an initial capacity of 40,000. It will be located in the Texas lignite fields on the Trinity River near Trinidad, about 65 miles southeast of Dallas, and will be in operation by the summer of 1926.

The company has bought or has under option about 3,000 acres of lignite beds located in the immediate vicinity of the plant site. It is believed this supply is sufficient to operate the station for twenty years, while other large beds of lignite now under option are available in the vicinity.

Philo, Ohio, Has First 600-Lb. Station In Operation

A 35,000-kw. turbine is now regularly carrying load at the Philo station of the Ohio Power Co. subsidiary of the American Gas & Electric Co. This is the first unit in this country to operate in a plant designed for 600-lb. steam pressure. The temperature of steam supplied is in the neighborhood of 725 deg. F. Steam is withdrawn after partial expansion and reheated to about initial temperature for the remainder of the expansion. Steam is extracted for heating the condensate. This is a single-cylinder, General Electric unit which has been operating regularly since Nov. 1, 1924.

N.E.L.A. Hydraulic Committee Plans Extensive Program

Definite plans were laid by the Hydraulic Power Committee of the Technical National Section of the N.E.L.A. at its meeting recently for work to be done by individual committee members as well as through co-operation of division committees as follows:

Survey of hydraulic power-plant layout; mechanical reliability of water-power units and plants; investigation of pitting of waterwheels; investigation of fish ladders; experience with different types of dams; results of draft-tube tests; keeping and interpreting operating records; forecasting water supply; bibliography of hydro-electric literature.

Among subjects suggested for future consideration were: Handling ice problems; handling trash; water hammer and surge tanks; speed regulation; relative fields of different types of waterwheels; progress reports on economies of back-water suppressor; vibration of waterwheels; settling basins and silt; recapitulation of hydraulic studies made by other societies.

Oil Production from Public Reserves Being Studied

The means for future production of oil from government reserves of coal and oil shale was the subject of a conference held at the Interior Department by technologists of the Navy, the Bureau of Mines and the Geological Survey. A research program to aid commercial development of processes by which oil may be obtained from oil shales, lignite, and other coal is being planned by the Bureau of Mines. The Navy was represented in the conference by Rear Admiral H. H. Rousseau, Commander N. H. Wright and Lt. Commander W. H. Osgood. The Geological Survey was represented by Dr. David White, W. T. Thom, Jr., fuels geologist, and W. H. Bradley, oil geologist. O. P. Hood, chief mechanical engineer in charge of the Fuels Division of the Bureau of Mines, presided.

A report was made upon recent research in foreign countries by A. C. Fieldner, superintendent of the Pittsburgh experiment station of the Bureau of Mines, who has just returned from a trip of inspection through European laboratories and carbonization plants. Reports were also rendered upon recent research in the fuels and petroleum laboratories of the Bureau of Mines.

Edison Medal Presented to John W. Howell

The Edison gold medal, which is awarded by the American Institute of Electrical Engineers, will be presented this year to John W. Howell, of the General Electric Lamp Works, Harrison, N. J., "for his contributions toward the development of the incandescent lamp." The presentation will take place during one of the evening sessions of the midwinter convention which is to be held in New York City Feb. 9-12.

The Edison medal was founded by the Edison Medal Association, which is comprised of associates and friends of Thomas Alva Edison, and is awarded annually "for meritorious achievement in electrical science and electrical engineering or the allied arts." Among those to whom the medal has been awarded are George Westinghouse, William Stanley, Alexander Graham Bell, Nikola Tesla, Cummings S. Chesney and others.

Valuation Engineer Needed by Government

The United States Civil Service Commission announces an open non-assembled competitive examination for valuation engineer, to fill a vacancy in the technical staff of the Income Tax Unit of the Bureau of Internal Revenue, at an entrance salary of $3,800 a year, with advancement in pay up to $5,000.

Separate registers will be established for the following lines of work: Oil and gas, coal, general mining, non-metals, mining, timber, pulp and paper, hydraulic and hydro-electric. The duties involve the estimation of the quantity; the theoretical and market value of the natural resource in place and its products; the value of equipment ordinarily used in the discovery, exploitation and utilization of such natural resources and the cost of development, exploitation and utilization of such natural resources.

Delaware River Agreement Virtually Established

The respective rights of New York, New Jersey and Pennsylvania to use water from the Delaware River are established in an agreement among the three states, the draft of which was virtually completed at Atlantic City on Dec. 5, according to press reports which have not been officially confirmed at this date.

The Tri-State Delaware Treaty Commission has been holding meetings for several months and has considered seventeen drafts of the proposed agreement. The final draft was said to be "in good shape and so formulated as to assure equitable distribution of the Delaware River water among the three states." The agreement, it was reported in the press, will provide generally that above the New York and New Jersey state line, or about Port Jervis, the three states will each have right to a third of the water supply above a reserve minimum level which will always be maintained.

New York will have a right to one-third of the water below the state line, provided such water flows into the Delaware from New York tributaries, while New Jersey and Pennsylvania each will have half of the water below the state line where such water comes from tributaries below the state line.

The minimum level provision applies throughout and the agreement, it is said, gives ample assurance of water supply for each state both for drinking and power purposes.

Lecture on High Temperature Insulation

Announcement was made last year that the Celite Products Company had prepared a lecture on "Heat Transfer and High Temperature Insulation," which was given at a large number of universities. Under the title of "High Temperature Insulation," a revised copy of this lecture has just been received. This contains somewhat more definite information on methods of determining heat flow through high temperature walls composed of various materials. The lecture, in its new form, has already been given at approximately 25 universities, with approximately 25 more listed for 1925.

Great Salt Lake Basin Has 100,000 Hp. Undeveloped

The report on the Great Salt Lake Basin, just issued as Water Supply Paper 517, prepared by Ralf R. Woolley, describes four undeveloped sites on Diamond Fork of Spanish Fork, which would yield 8,900 hp. for 90 per cent of the time and 11,700 hp. for 50 per cent of the time. On Logan River three undeveloped sites would yield 11,400 hp. for 90 per cent of the time and 19,300 hp. for 50 per cent of the time. On Weber River four undeveloped sites would yield 9,150 hp. for 90 per cent of the time and 11,600 for 50 per cent of the time. These estimates are based on the present flow unregulated. On Bear River, with regulated flow, four undeveloped sites would yield 21,000 hp. for 90 per cent of the time and 30,000 hp. for 50 per cent of the time.

The total capacity of undeveloped sites in Great Salt Lake Basin is 81,000 hp. for 50 per cent of the time and 56,000 hp. for 90 per cent of the time with existing flow and 115,000 hp. for 50 per cent of the time and 80,000 hp. for 90 per cent of the time with regulated flow. Developed and undeveloped sites in the basin are described in the report, which also gives such information relative to the use of water in irrigation and to the market for power as will afford a basis for a correct estimate of the present and future value of the water-power resources of the basin and of the possibilities for profitable water-power development.

In 1900 the installed capacity of the water-power plants in the Great Salt Lake Basin was about 14,000 hp.; in 1923 it was more than 225,000 hp.

Tentative Rules Laid Down on Standard Symbols

A joint meeting of the Power Test Codes, Individual Committee No. 2 on Definitions and Values and the A.S.M.E. Group of Sectional Committee on the Standardization of Scientific and Engineering Abbreviations and Symbols was held on Dec. 2, during the A.S.M.E. meetings, to consider standard symbols. Present at the meeting were: Dr. Sanford A. Moss, Robert Fernald, Dr. Lionel S. Marks, Harvard N. Davis, F. J. Schlink, Herbert B. Reynolds, Prof. F. O. Ellenwood and R. J. S. Pigott. A report of the meeting states:

The great difficulty in getting standard symbols is to establish any kind of logical criterion by which symbols may be chosen, so as to take into account national or international custom, mnemonics. repetition and convenience in typing or printing. After an extended discussion, the following set of tentative rules was laid down, which should afford a working basis for selecting standard symbols.

Wherever convenient for distinguishing between specific quantities and extensities, or aggregates, the lower case letter should be used for the specific quantities, and capitals for the extensities.

It is desirable to avoid the use of Greek letters as far as possible, with the exception of Θ and ϕ, which can be fairly conveniently written on the typewriter.

It is desirable to have international agreement in symbols, but this should not be the controlling reason for adoption. National use should be given greater consideration. In some cases where it is desired to use another symbol than the one already adopted by the International Electrotechnical Commission, the method already adopted by the Commission can be used for our work, i.e., giving alternative symbols, one of which would be the international standard; the other, the one we prefer. The use of subscripts is preferred for distinguishing between different quantities involving the same letter symbol. The use of primes should be permitted, as their use is necessary at times, but should be discouraged as much as possible. A footnote covering this point should be appended to the table, and both methods of indication should be employed in the table, giving the subscripts the first or preferred position. In the Codes the preferred symbols should be used exclusively.

The list of symbols to be prepared by the Joint Committee should include only those actually required at the present time in the Power Test Codes, in order to minimize the risk of establishing symbols not actually necessary at this time, which might later be reversed in international lists.

On the adoption of all symbols, joint action of the two committees should be taken, and all suggested lists should be circulated to the full membership of both committees for approval.

In general, subscript letters should be employed for specific states and subscript numbers for specific points or locations in the apparatus.

A discussion in detail of the symbols recommended by the Symbols Committee in their letter of Aug. 12, 1924, and incorporated in the galley proof of the Definitions and Values Committee, subject to the approval of the members of this Committee, followed:

The use of h for heat content appeared to be generally acceptable, it being noted that Professor Goodenough was apparently the only one who used the letter i.

The letter r for latent heat of vaporization was also considered satisfactory.

The letter u was opposed by practically all members present, largely on the grounds that if there is to be any attempt to make use of the mnenonic principle, the use of the letter u in this case (which is derived from the German word umformungsenergie) would immediately spoil the practice as far as English is concerned.

While this is certainly not a logical stand to take on the grounds of international adoption, it was recognized by the Committee that it is practically impossible to be generally logical in setting up these standards. Dr. Moss advanced the thought that, as far as possible, we should give considerable weight to the symbols adopted by the old masters who originated them, but the discussion brought forth that any such policy would be both difficult and inconvenient to follow, especially in view of the fact that great departures from the original symbols are in considerable use.

The letter i is looked upon as satisfactory for use in representing internal energy of saturated vapor. The letters c_p and c_v for the specific heats are considered satisfactory.

γ for ratio of specific heats is in such general use in this country that it would be difficult to drop it absolutely. However, fortunately, k is also largely used, and the use of k for the preferred letter and γ for the second choice was adopted.

The letter s for entropy was considered unsatisfactory. The letter n was adopted as the preferred symbol, and ϕ for the alternative.

The letters p, J, A and Q were considered satisfactory. Professor Ellenwood objected to the form of definition for J, but it was pointed out that while it is recognized to be inexact in statement, it is understood by everybody in the form as given.

The use of T for absolute temperature, and t for fahrenheit temperature was considered satisfactory, inasmuch as specific quantities and extensities are not involved.

The use of W for work and w for weight aroused some objections, but it was finally decided, as there was no more satisfactory way of covering these two quantities.

The use of η aroused considerable objection generally, on the grounds that it was not possible to type it, and is usually mistaken for the small n. The only support for using it is that it has already been adopted by the International Electrotechnical Commission. It was therefore decided to use the letter e as the preferred symbol, with η as alternative.

The use of v for specific volumes was considered satisfactory, with the letter u for difference of volumes during vaporization at constant pressure, Professor Davis remarking that it was not to be considered good practice using the same letter for a difference between two specific quantities as was used for the quantities themselves. This was the reason, for example, why the letter r was used for latent heat of vaporization, instead of the letter h.

Discussion of these tentative symbols is invited. Communications may be addressed to R. J. S. Pigott, 120 Broadway, New York City.

Mining Engineers Award Gold Medal

William M. Bassett, metallurgist of the American Brass Co., Waterbury, Conn., has been awarded the James Douglas gold medal by the American Institute of Mining and Metallurgical Engineers. The medal is bestowed annually for distinguished achievement in non-ferrous metallurgy.

Exports of Power Machinery to Venezuela Increase

A gradually expanding market for boilers and steam-power plant accessories and for internal-combustion engines and parts in Venezuela is indicated by United States customs figures giving American exports of power-generating machinery (except electric) to that country for 1923 and for the first half of 1924.

The following table gives exports of power-generating machinery (except electric) to Venezuela for the first six months of 1923 and 1924:

UNITED STATES EXPORTS OF POWER-GENERATING MACHINERY, EXCEPT ELECTRIC, TO VENEZUELA

Class	January to June, 1923	January to June, 1924
Steam engines:		
Stationary, except turbines	$2,327	$12,190
Marine, except turbines	.....	184
Other engines, accessories and parts	7,788	14,467
Boilers	26,052	65,494
Condensers, heaters and accessories	135	1,450
Injectors, gauges, safety valves and other boiler accessories and parts	6,201	33,084
Internal-combustion engines:		
Stationary and portable Diesel and semi-Diesel	4,850	640
Other stationary and portable over 10 horsepower	3,123	24,399
Marine, except detachable	4,016	2,562
Accessories and parts	6,355	9,725
Water wheels and water turbines under 500 horsepower	2,720	2,961
Total	63,567	167,156

In addition to the increases already noted, conveying machinery exports to Venezuela showed a slight gain in 1923 over the preceding year, and a still further increase, according to half-year figures, for 1924. Refrigerating machinery exports increased from $10,962 in 1922 to $49,786 in 1923.

Pumping machinery alone increased in value of shipments to Venezuela about 65 per cent in 1923 over 1922. The following table of exports gives further details.

UNITED STATES EXPORTS OF PUMPING MACHINERY TO VENEZUELA

Class	1922	1923	Jan.-June, 1924
Pumps:			
Centrifugal	4,971	3,292	4,479
Steam	9,258	41,175	22,922
All other power pumps	26,371	21,673	97,277

Power Show Splendid Success This Year

The Third National Exposition of Power and Mechanical Engineering, which was held at the Grand Central Palace during the first week in December, had a total attendance of 79,000. The first exposition, held in 1922, had an attendance of 48,000 and the second exposition, in 1923, an attendance of 62,000. The Show was a splendid success and easily the most interesting exposition held in the Grand Central Palace during the year.

New York Water Power Law Questioned

The Public Service Commission announced on Dec. 16 the first decision affecting the rights of a private corporation under the eminent domain provisions of the Robinson water power law of New York State, deciding that certain lands and water rights on the Salmon River in the town of Orwell, Oswego County, owned by R. W. Horton and others, are necessary for the development of a single water-power site by the Niagara, Lockport & Ontario Power Co. under the provisions of the Water Power Act of 1921. This decision under the act is prerequsite to the exercise of the right of eminent domain for the acquisition of these properties. The lands and water rights are privately owned, and are no part of the state's natural resources.

The constitutionality of the law was attacked by the land owners, but the Commission held that it was without power to pass upon this question. The constitutionality of the act is left for the courts to determine.

In its decision the Commission says: "In this enactment of the Legislature the State has announced its policy to be that water rights may be acquired in certain instances when in the interest of the public by the exercise of the right of condemnation not only by the state itself but also by private corporations engaged in the production of light, heat and power for public use."

The evidence shows that the Niagara company owns 28 ft. of the head of 50 ft. within the project area, the Hortons owning the remaining 22 ft. It also shows that the Niagara power site is capable of developing approximately 10,000 hp. whereas the power site claimed by the Hortons would develop about 3,000 hp. The development of the Horton site would prevent the development of the Niagara site, and likewise the development of the Niagara site would prevent the Horton development. The Commission points to the language in the statute as an indication that the legislature had in mind the development of separate water-power sites into a single development for the production of power for public uses, to the end that power may be generated at the last production cost, and asserts that public interest will be best served by development of the larger site.

This is the first case which has come up for decision under the provisions of the eminent domain feature of the Robinson law.

Exchequer Power Plant Contracts Let

Prime mover and generator equipment for the Exchequer hydro-electric plant of the Merced Irrigation district were recently placed on order. The plant is located on the Merced River, 35 miles east of Merced, Calif., and will contain two 24,500-hp., vertical reaction turbines, driving direct-connected 15,000-kva. generators. The turbine equipment was awarded to the Pelton Water Wheel Co. of San Francisco and will embody the most advanced features of design that have been developed by this company and the I. P. Morris department of the Cramp Company of Philadelphia. The generators will be furnished by the Westinghouse Electric & Manufacturing Co. and the transformers by the General Electric Co.

Because of the fact that irrigation will take precedence of power in the Exchequer development, the turbines will be designed to provide best efficiency under heads ranging from 300 ft. maximum to 140 ft. minimum. In normal years the reservoir will provide enough storage to run the plant at full capacity for five months. After the head has reached the minimum the plant will be shut down.

The power will be stepped up to 120,000 volts and tied in through a transmission line with the system of the San Joaquin Light & Power Corp. which will absorb the entire output of the plant. The San Joaquin Light & Power Corp. has recently been merged with the Great Western Power Corp. of New York.

Obituary

TenBroeck Williamson Stinson, consulting mechanical engineer of Public Service Production Co., died in the Jersey City Hospital on Nov. 26. Death was caused by peritonitis following an operation for appendicitis a week previous. Mr. Stinson was born Sept. 24, 1889, in Manalpan, N. J., attended the Horace Mann School in New York City and then entered Worcester Academy to prepare for Stevens Institute of Technology, completing the mechanical engineering course with the class of 1912. Upon leaving college, he entered the engineering department of the Public Service Electric Co. In 1915, when the first section of the Essex Station was being built, he was made assistant construction superintendent and held that position until 1916, when he was promoted to assistant engineer attached to the general office staff. In 1920 he was appointed mechanical engineer in charge of designs for the extension and improvements then being carried on by the Public Service Electric Co. When the Public Service Production Co. was formed in February, 1922, Mr. Stinson became consulting mechanical engineer, and he was in responsible charge of all mechanical and building designs for the company until the time of his death. He was a member of the A.S.M.E., the N.E.L.A., and the Beta Theta Pi Fraternity. Endowed with a charming personality and a kindly manner, he will be greatly missed by his many social and professional friends.

Personal Mention

David S. Wegg, of Chicago, has been appointed assistant chief of the Electrical Equipment Division of the Bureau of Foreign and Domestic Commerce.

Charles Piez, chairman of the board of the Link-Belt Co., Chicago, Ill., has recently been nominated for president of the Illinois Manufacturies Association and will be elected at its December meeting.

D. L. Fagnan, who has been prominently identified for some years with the N.A.S.E., has entered the Smoot Engineering Corp., 136 Liberty St., New York City, in the capacity of service engineer for central stations and power plants.

F. B. Jewett, past president of the A.I.E.E. and vice-president of the Western Electric Co., was recently elected vice-president in charge of research and development of the American Telegraph and Telephone Co.

Francis C. Pratt, vice-president in charge of engineering of the General Electric Co. has been appointed to fill the vacancy caused by the resignation of G. E. Emmons, as vice-president in charge of manufacturing and chairman of the manufacturing committee.

Peter William Sothman, who was connected as chief engineer with the Hydro-Electric Power Commission of Ontario for several years and other public utilities in this country and abroad, has recently become connected with the M. H. Avram & Co., industrial engineers of 25 Broad St., New York City.

Dr. Edward Curtis Franklin, professor of organic chemistry in Leland Stanford University, Calif., has been awarded the Nicholas medal which is given "for the research published during the current year, which in the opinion of the jury is most original and stimulative to further research," by the American Chemical Society.

C. C. Hermann, Waterloo, Iowa, who was formerly connected with Deer & Co., Moline, Ill., and who for the last five years has been engineer and general superintendent of the Litchfield Manufacturing Co., Waterloo, has resigned his position to devote his time to consulting engineering, specializing in boiler-plant design and fuel-oil burning. He also expects to give some time to development, research and invention along mechanical and industrial lines.

Society Affairs

The Seattle Section of the A.I.E.E. will hear Major Joseph Jacobs on "Engineering and Economic Features of the Proposed Columbia River Basin," at its Jan. 21 meeting.

The Cleveland Section of the A.S.M.E. will hold an all-day meeting at the Hotel Winton on Jan. 13. "Symposium on Pulverized Coal," with several speakers will be the attraction.

The New England Water Works Association, Frank J. Gifford, Tremont

Temple, Boston, Mass., will have as the attraction for its Jan. 13 meeting, "Corrosion," by Frank N. Speller, and "Remedial Measures to Correct Corrosion in the Coolgardie Pipe Line in Australia," by Col. Francis F. Longley.

The Empire City No. 1, N.A.S.E., is the new organization that has been formed by the combination of the former Associations No. 1, 7, 15, 23, 24 of the N.A.S.E. of New York City.

Engineering societies and their local sections can obtain, free of charge for exhibition, the film "Power," which graphically describes in a non-technical way the development of steam from its first public uses 150 years ago to its great position as a power in the present economic life of the world, by writing to Stone & Webster at 147 Milk St., Boston, Mass.

The Chicago Section of the A.S.M.E., which is to hold a Power meeting Jan. 14 and 15, a program of which was published in the Dec. 16 issue, will have additional papers which were not listed. One is "Boiler and Turbine Auxiliaries," by G. G. Bell, manager of power development of the West Penn Power Co., Pittsburgh; the other is "Water Cooled Furnace Walls," by H. O. Savage, of the Combustion Engineering Corp.

Business Notes

The Foote Bros. Gear & Machine Co., Chicago, Ill., is erecting an addition to its plant with an entrance on Lake St.

The Link Belt Co., 910 South Michigan Ave., Chicago, Ill., announces that its St. Louis branch has recently moved from 705 Olive St. to 3638 Olive St.

The Conveyors Corp. of America, 326 West Madison St., Chicago, Ill., announces the appointment of C. S. Price, First Nat'l Bank Bldg., Hazleton, Pa., as its district representative for northeastern Pennsylvania. Associated with Mr. Price in the sale of the American steam jet ash conveyor is E. E. Elliott.

The Sullivan Machinery Co., 122 South Michigan Ave., Chicago, Ill., has changed the location of its Cleveland office, Ralph T. Stone, manager, from room 824 to 701 Rockefeller Building. It is also announcing the establishment in Los Angeles of a branch office and warehouse at 412 East Third St., with Benjamin P. Lane as local manager.

The Elliott Co. Takes Over Kerr Turbines.—Some time ago certain of the larger stockholders of Elliott Co., Pittsburgh, Pa., became financially interested in the Kerr Turbine Co., Wellsville, N. Y., and recently acquired a very large controlling interest in that company. In view of the close financial relations existing between the controlling interests of the companies, it was logical for Elliott Co. to take over the interest held by its stockholders in the Kerr Turbine Co., thereby adding Kerr turbines to its line of power-plant equipment. Kerr turbines will continue to be manufactured at the Kerr plant, under the direction of Elliott Co., and the engineering and manufacturing organization at Wellsville will be retained.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution, Washington, D. C. Meeting at Washington, Dec. 29-Jan. 3.

The American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Midwinter meeting at Cleveland on Feb. 12.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

The American Engineering Council. L. W. Wallace, 24 Jackson Place, Washington, D. C. Annual meeting at Washington, D. C., Jan. 16-17.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 22-26.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 33 West 29th St., New York City. Annual meeting at Boston, Jan. 28-30.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th New York City, April 27 to May 2, formerly announced for Dec. 8-13.

Illinois Society of Engineers. E. R. Tratman, Wheaton, Ill. Meeting at Chicago, Jan. 14-16.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

The National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **New England States Association** at Worcester, Mass., June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

National Marine Engineers Beneficial Association, Geo. A. Grubb, 313 Machinists Building, Washington, D. C. Convention at Hotel Franklin Sq., Washington, D. C., Jan. 19.

Society of Automotive Engineers. C. F. Clarkson, 29 West 39th St., New York City. Annual meeting at Detroit, Mich., Jan. 20-23.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Trade Catalogs

Cement—The Atlas Lumnite Cement Co., 25 Broadway, New York City. "24 Hour Cement" is the title of a recent catalog published by this company. Copies may be obtained on request.

Diesel Engines—Fulton Iron Works, St. Louis, Mo. "The Diesel Engine in Medium-Powered Central Stations," by Ray C. Burrus, is the reprint from a paper read before the St. Louis Section of the A.S.M.E.

Air-Preheater — James Howden & Company of America, Inc., Wellsville, N. Y. Bulletin No. A-5 describes the Howden-Ljungstrom patent air preheater. The bulletin is illustrated with good photos of the entire preheater, cross-sections and individual parts.

Gear Drives—Mesta Machine Co., Pittsburgh, Pa. Bulletin "B" is a well illustrated description of the process of manufacture of double-helical cut teeth gear drives, and installations made by the company and may be obtained upon application.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

	Market	Dec. 8, 1924	Dec. 15 1924
Coal, net tons.	Quoting		
Pool 1.....	New York...	$3.00	$2.95
Smokeless.....	Columbus....	2.25	2.25
Clearfield.....	Boston.....	2.35	2.25
Somerset.....	Boston.....	2.40	2.40
Kanawha.....	Columbus....	1.65	1.65
Hocking.....	Columbus...	1.75	1.75
Pittsburgh No. 8	Cleveland....	1.90	1.90
Franklin, Ill.....	Chicago.....	2.50	2.50
Central, Ill.....	Chicago.....	2.25	2.25
Ind. 4th Vein...	Chicago.....	2.50	2.50
West Ky.....	Louisville....	1.75	1.75
S. E. Ky.....	Louisville....	1.75	1.50
Big Seam.....	Birmingham..	1.90	1.75

FUEL OIL

New York—Dec. 18, light oil, tank-car lots; 28@34 deg. Baumé, 5c. per gal.; 36@40 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Dec. 9, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl.; 26@28 deg., $2.00 per bbl.; 28@30 deg., $2.05 per bbl.; 30@32 deg., $2.10 per bbl.; 32@36 deg., gas oil, 5½c. per gal.; 38@40 deg., 6¼c. per gal.

Pittsburgh—Dec. 8, f.o.b. local refinery; 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.

Dallas—Dec. 16, f.o.b. local refinery, 26@30 deg., $1.20 per bbl.

Philadelphia—Dec. 12, 28@30 deg., $2.10@$2.163 per bbl.; 18@20 deg., $1.87½@$1.93¾; 13@16 deg., $1.764@$1.827 per bbl.

Boston—Dec. 15, tank-car lots, f.o.b.; heavy oil, 12@14 deg. Baumé, 4½c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati—Dec. 9, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¾c. per gal.; 26@30 deg., 5¾c. per gal.; 30@32 deg., 6½c. per gal.

Chicago—Dec. 16, tank-car loads, delivered within city limits, 20@22 deg., 6c. per gal.; 24@26 deg., 6c.; 28@30 deg., 6½c.; 30@32 deg., 6¾c. per gal.

New Plant Construction

Calif., Compton—Compton Union High School Dist., A. Herskind, Clk., will receive bids until Dec. 30 for one 500 gal. centrifugal pump, one 25,000 gal. hemispherical bottom steel tank on 50 ft. tower with equipment, one 30 hp. vertical motor, strainer, etc.

Calif., El Centro—Delno Ice Co. awarded the contract for the construction of an ice manufacturing plant, to Union Iron Works, 5125 Santa Fe St., Los Angeles, estimated cost $45,000.

Calif., El Segundo — The City is having plans prepared for the construction of a combined gravity and pumping sanitary sewer system. R. T. Hutchins is city engineer.

Calif., Los Angeles—The City Harbor Comn., plans to purchase pumping equipment for installation at Fish Harbor to handle refuse of canneries, pump to have capacity of at least 5,000 g.p.m., estimated cost between $12,000 and $20,000.

Calif., Los Angeles—Curlett & Beelman, Union Bank Bldg., Archts., are receiving bids for the construction of an 11 story, 330 x 107 ft. stores and loft building on 7th St., for the Sun Realty & Investment Co.

Calif., Los Angeles—W. P. Fuller & Co., 135 North Los Angeles St., manufacturers of paint, are receiving bids for the construction of a 4 story warehouse at San Fernando Rd. and Barranca St., including 4 electric elevators, complete refrigeration and steam heating system, estimated cost $350,000. Morgan, Walls & Clements, 1124 Van Nuys Bldg., are architects.

Calif., Oakland—G. Jamieson, c/o M. I. Diggs, 19th and Telegraph Ave., Archt., will build a 12 story apartment in the Lake Merritt district, estimated cost $750,000. Work to be done by separate contracts.

Calif., Porterville—Vandalia Irrigation Dist., H. C. Pegram, Secy., will receive bids until Jan. 7 for furnishing 3¼ mi. electric power line carrying 2,200 v.; 125, 75 and 40 hp. horizontal, 2,200 v., 3 phase, 60 cycle, 1,800 r.p.m. motors; one 3,300 g.p.m. 115-ft. head, one 2,100 g.p.m. 115-ft. head, one 800 g.p.m. 140-ft. head pumps; 5 deep well turbine pumps 900 g.p.m. 110-ft. head, 50-ft. column, fully equipped and installed with 2,200 v., 3 phase, 60 cycle, 1,200 r.p.m. motor. I. H. Althouse, is engineer.

Calif., Santa Monica—A. I. Jordan, 111 West Washington St., Chicago, Ill., is having plans prepared for the construction of an 11 story hotel at corner of Ocean and California Aves., including complete refrigeration and steam heating system, boilers and 2 electric elevators, estimated cost $1,500,000. J. Armstrong, 38 South Dearborn St., Chicago, Ill., is architect.

Calif., Wilmington—Latin-American Fruit & Steamship Corp., 1215 Hibernian Bldg., Los Angeles, plans the construction of a pre-cooling plant and conveyor system, estimated cost $150,000.

Conn., South Manchester—Lockwood, Greene & Co., Engrs., 24 Federal St., Boston, Mass., awarded the contract for the construction of a service building, including a temporary boiler room, for The Manchester Memorial Hospital, to the Manchester Construction Co. Later on a power plant will be built.

D. C., Washington—A. L. Flint, Gen. Purch. Officer of the Panama Canal, will receive bids until Jan. 8, 1925 for diesel engine driven generator equipment for stand-by generator stations.

Ill., Bloomington—C. U. Williams & Son, 207 West Washington St., manufacturers of Oil-O-Matic heating apparatus, will build by day labor a heating plant, estimated cost $40,000. A. T. Simmons c/o owner, is architect.

Ill., Chicago—St. Scholastica Academy, 7430 Ridge Blvd., awarded the contract for the construction of a boiler house, laundry and garage building in Rogers Park, to M. Raven, 111 West Washington St., estimated cost $50,000.

Ia., Mitchell—Northeastern Iowa Power Co., West Union, awarded the contract for the construction of a dam and power house to A. R. Coffeen, Decorah, estimated cost $250,000. Two 500 kva. units to be installed. This company is also at work on a smaller power plant at Greene.

Kan., Cuba—The City will receive bids in January for a waterworks system, including pumping equipment, tank on tower, distribution system, etc., estimated cost $38,000. C. A. Haskins, 517 Finance Bldg., Kansas City, Mo., is engineer.

La., Arabi — The Police Jury of St. Bernard Parish, plans to purchase and install a new pumping plant near the mouth of Terre Bayou, Boeuff, for the water supply, estimated cost $2,000.

La., New Orleans—Bd. of Sewerage and Water Wks., A. G. Moffat, Secy. and Treas., Sewerage and Water Bldg., will soon receive bids for 1,400 g.p.m. boiler feed water pump, steam turbine driven complete on base plate; 200 g.p.m. boiler feed water pump, for steam turbine operation; 2,800 g.p.m. centrifugal pump, motor driven, complete on base plate.

Mass., Boston 390 Beacon St., Inc., c/o C. A. Isenback, 120 Milk St., is receiving bids for the construction of an 11 story apartment hotel, estimated cost $1,500,000. J. C. Spofford, 36 Bromfield St., is architect.

Mass., Boston—Lockwood, Greene & Co., Engrs., 24 Federal St., Boston, are receiving bids for a 2 story, 42 x 78 ft. extension to plant and a 53 x 51 ft. boiler house for the Eastern Steam Laundry Co., 941 Massachusetts Ave., Boston.

Mass., Boston—J. A. Rouke, Comr., Public Works Dept., City Hall, will receive bids until Jan. 6, 1925 for electrical equipment for No. 1 and No. 2 pumping units at Calf Pasture Pumping Station, estimated cost $15,000.

Mass., Tully — F. C. Warrick & Co. awarded the contract for the construction of a 2 story power house and factory, to Taylor Wheeler Corp., Starrett Bldg., Athol, estimated cost $55,000.

Mo., Fredericktown—The City will receive bids in January for the construction of a new waterworks plant, tank on tower, pumps and distribution mains, etc., estimated cost $112,000. C. Haskins, 517 Finance Bldg., Kansas City, is engineer.

N. H. Portsmouth—Bureau of Yards & Docks, Navy Dept., Washington, D. C., L. E. Gregory, Chf., will receive bids early in 1925 for electrically driven capstans at the Navy Yard.

N. J., Jersey City—National Grocery Co., 480 Montgomery St., will soon receive bids for the construction of a 5 story warehouse including a cold storage plant on Mercer St., estimated cost $500,000. R. W. Sailer, 76 Montgomery St., New York, is architect and engineer.

N. Y., New York—R. M. Catts Syndicate, c/o Warren & Wetmore, 16 East 47th St., Archts., awarded the contract for the construction of a 25 story office building on Madison Ave. between 35th and 36th Sts., to D. P. Robinson, 125 East 46th St., estimated cost $6,000,000.

N. Y., New York—1107 5th Ave. Corp., c/o Rouse & Goldstone, 512 5th Ave., Engrs. and Archts., awarded the contract for the construction of a 14 story apartment house at 92nd St. and 5th Ave., to G. A. Fuller Corp., 175 5th Ave., estimated cost about $1,000,000.

N. Y., New York—353 Lexington Ave. Corp., c/o Schwartz & Gross, 347 5th Ave., Archts. and Engrs., is having plans prepared for the construction of a 11 story apartment house at 349 Lexington Ave., estimated cost $500,000.

O., Cincinnati—S. Hannaford & Sons, 1024 Dixie Terminal Bldg., Archts., will receive bids until Dec. 29 for the construction of a 6 story hospital on Middleton St., for the Bethesda Hospital, 122 East 4th St., estimated cost $600,000.

O., Cleveland—The Cleveland Electric Illuminating Co., Illuminating Bldg., J. Wolf, has had plans prepared for the construction of a 90,000 hp. electric generating station at Avon Beach, to be equipped with steam boilers and to burn pulverized coal, estimated cost $10,000,000. The contract for structural steel has been awarded to the American Bridge Co., 30 Church St., New York, McClellan & Jungerfeld, 68 Trinity Place, New York, are engineers.

O., Cleveland—The City, W. K. Hoare, City Hall, is in the market for 2 boiler superheaters.

O., Columbus—The Ohio Edison Co., Springfield, has obtained permission from The Ohio Utilities Comn., to issue $250,000 in stock and $400,000 bonds to capitalize treasury expenditures and for extensions and betterments to the power company.

O., Painesville—The City is having plans prepared for new filters, 1,000,000 gal. capacity, centrifugal pumps, etc., estimated cost $125,000. Hadlow, Hick & Co., Finance Bldg., Cleveland, are engineers.

Okla., Chandler—L. D. Gray, Engr., will receive bids until Jan. 15, for complete equipment for a 20-ton ice plant to replace that recently destroyed by fire, for the Chandler Ice Co., estimated cost $30,000.

Okla., Fairfax—C. J. Hoffaker will receive bids Dec. 31 for 6 miles of 13,200 v. electric transmission line from Ralston to Fairfax together with transformer stations at each end of line, estimated cost $25,000.

Okla., Fort Sill—Office of the Constructing Quartermaster awarded the contract for the construction of 3 boiler houses and heating plants, to F. B. Hannan, Lawton, estimated cost $35,900.

Okla., Hollis—The City is receiving bids for a new water supply system, 9 miles northwest of here, estimated cost $100,000. Gant Baker Co., 1116 West Main St., Oklahoma City, is engineer. Two motor driven pumps will be installed.

Okla., Quinton—The City plans an election on Jan. 9 to vote $16,000 bonds for the construction of a new rapid sand water purification plan, elevated tank and 150 g.p.m. triplex pump. V. V. Long & Co., Colcord Bldg., Oklahoma City, are engineers.

Tex., Canyon—Kelso-Wurdack Co., M. Kelso, Mgr., will build an ice plant, estimated cost $51,000. Private plans.

Tex., Dallas—Long & Witchell, American Exchange Bldg., Archts., will soon receive bids for the construction of a 20 story office and theatre building on Elm St., for Singer & Bissinger Co., c/o Queen Theatre Bldg., estimated cost $1,000,000.

Tex., Lubbock—Texas Utilities Co., H. L. Allen, Mgr., plans construction of an addition to light plant at Ave. K and 10th St., increasing capacity, and will purchase a 1200 hp. Bush-Sulzer Bros. diesel engine. Will also construct a 50-ton ice freezing plant.

Tex., Paducah—The City, J. W. Carroll, Mayor, is having plans prepared for waterworks improvements, including pumping plant, well, mains, etc., estimated cost $125,000. Gantt-Baker Co., 1116-18 West Main St., Oklahoma City, Okla., are engineers.

Tex., San Antonio — T. B. Baker, c/o Gunter Hotel, plans the construction of a cold storage plant on Medina St., estimated cost $150,000. Engineer not selected. Owner will purchase machinery.

Tex., San Antonio—M. F. Postlewaite, c/o Southern Ice & Cold Storage Co., plans the construction of an ice plant on Medina St., 100 tons daily, estimated cost $150,000. Engineer not selected. Owner will purchase machinery.

Wash., American Lake—U. S. Veterans Bureau, Washington, D. C., will receive bids until Dec. 30 for the construction of a refrigeration plant at the U. S. Veterans Hospital No. 94.

Wis., Cambria—Cambria Canning Co., H. Schimmel, Pres., awarded the contract for the construction of a group of buildings, including a boiler house, to J. Kumn, Columbus, Wis., estimated cost $150,000.

Wis., Milwaukee—The City plans to rebuild the North Point pumping station to provide for increased boiler capacity, additional boilers will be installed. Estimated cost $200,000.

Wyo., Sheridan—U. S. Veterans' Bureau, Washington, D. C., will receive bids until Dec. 30 for the construction of an ice making plant for the U. S. Veterans' Hospital No. 86.

Ont., Sudbury—The City plans the construction of a waterworks system and filtration plant, including electric centrifugal pumps, estimated cost $30,000. F. C. Lane is engineer.

Que., Sherbrooke—Leyland Hotel System, Rochester, N. Y., is having plans prepared for the construction of a 6 story hotel on East Wellington St., estimated cost $750,000. H. L. Stevens & Co., 522 5th Ave., New York City, are architects.